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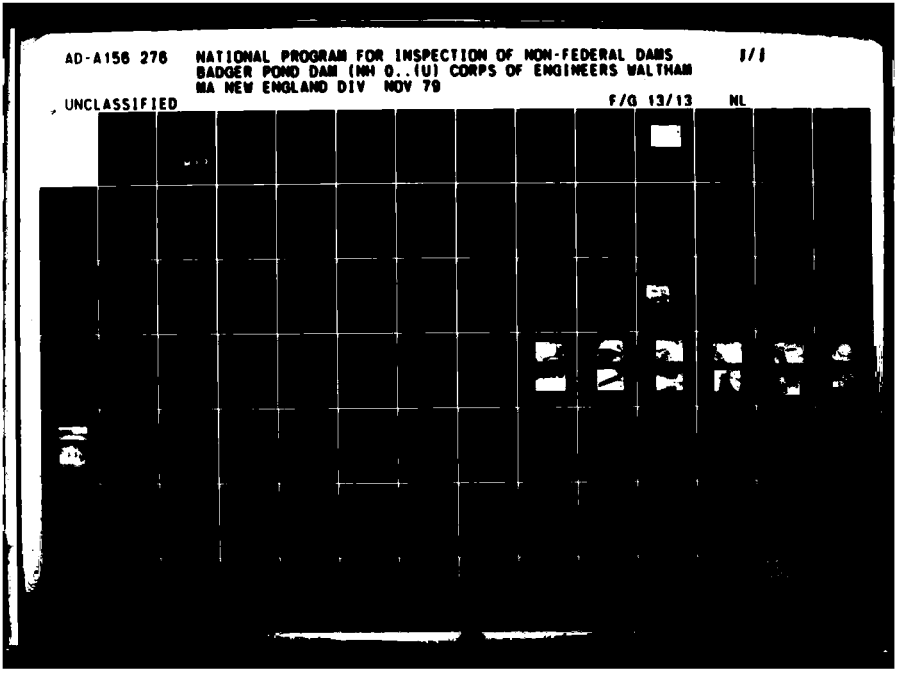

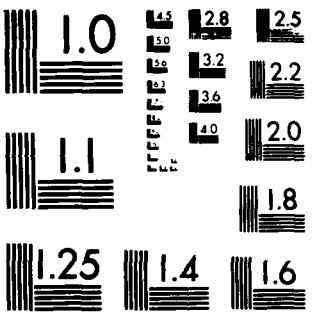

MERRIMACK RIVER BASIN

BELMONT, NEW HAMPSHIRE

BADGER POND DAM
N.H. 00085

STATE NO. 21.02

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

NOVEMBER 1979

UNCLASSIFIED

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Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Merrimack River Basin
Belmont, New Hampshire
Tioga River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam has a hydraulic height of 21 ft. and is 260 ft. long. The dam is in fair condition. Seepage near the downstram rockfill buttress and the north abutment are among major concerns. It is small in size with a high hazard classification. A major breach at spillway crest would probably result in the loss of 10 or more lives and could cause exstensive property damage.

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REPLY TO
ATTENTION OF
NEDED

MAY 19 1980

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

Inclosed is a copy of the Badger Pond Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Mr. James Locke, Campton, New Hampshire 03223.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	NH0085
Name of Dam:	Badger Pond Dam
Town:	Belmont
County and State:	Belknap County, New Hampshire
Stream:	Tioga River
Date of Inspection:	September 7, 1979

BRIEF ASSESSMENT

Badger Pond Dam has a hydraulic height of 21 feet, is 18 feet wide at the crest, and is 260 feet long. It is a rockfill concrete-walled embankment with a concrete capped masonry spillway. The spillway is located in about the center of the dam and is 120 feet long. A change in alignment occurs in the spillway approximately 75 feet from the south abutment. The dam impounds Badger Pond and the discharge from the dam forms the Tioga River. The dam is located in central New Hampshire. Maximum storage capacity is about 510 acre-feet. Badger Pond Dam, at present, is used for conservation purposes. The pond is 0.2 mile in length with a normal pool surface area of about 20 acres.

The dam is in fair condition. Major concerns are: seepage near the downstream rockfill buttress and the north abutment; trees growing on the upstream and downstream slopes at the end of the dam, in the rockfill buttress at the north end of the dam, and near the downstream toe of the dam at both the north and south ends of the dam embankment; lack of vegetation, and, therefore, erosion protection on the crest of the embankment section at the south end of the dam; operability of the low-level outlet mechanisms and the partially blocked outlets, and deteriorated areas of concrete on the spillway, non-overflow sections, and control tower.

Based on small size and high hazard classification in accordance with Corps guidelines, the test flood ranges from ½ to the Probable Maximum Flood (PMF). Because of the potential loss of lives in event of a breach, the PMF was selected as the test flood. The test flood inflow, using the 'mountainous' guide curve and the PMF outflow from the Sargent Lake Dam inspection report, was determined to be 30,930 cfs (1933 csm). After routing, the test flood outflow was determined to be 30,580 cfs (1906 csm) at elevation 590.5' MSL. This test flood would overtop the dam by 7.5 feet (13.5 feet over spillway crest). The spillway capacity at top of dam is 4,760 cfs or 16 percent of the routed test flood discharge. A major breach at spillway crest would probably result in the loss of 10 or more lives and could cause extensive property damage. (See Section 5.1 f.)

The owner, Pascoe Roberts, should implement the results of the recommendations and remedial measures given in Sections 7.2 and 7.3 within one year after receipt of this Phase I Inspection Report.

Warren A. Guinan
Project Manager
N.H. P.E. 2339

This Phase I Inspection Report on Badger Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

RICHARD DIBUONO, MEMBER
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, CHAIRMAN
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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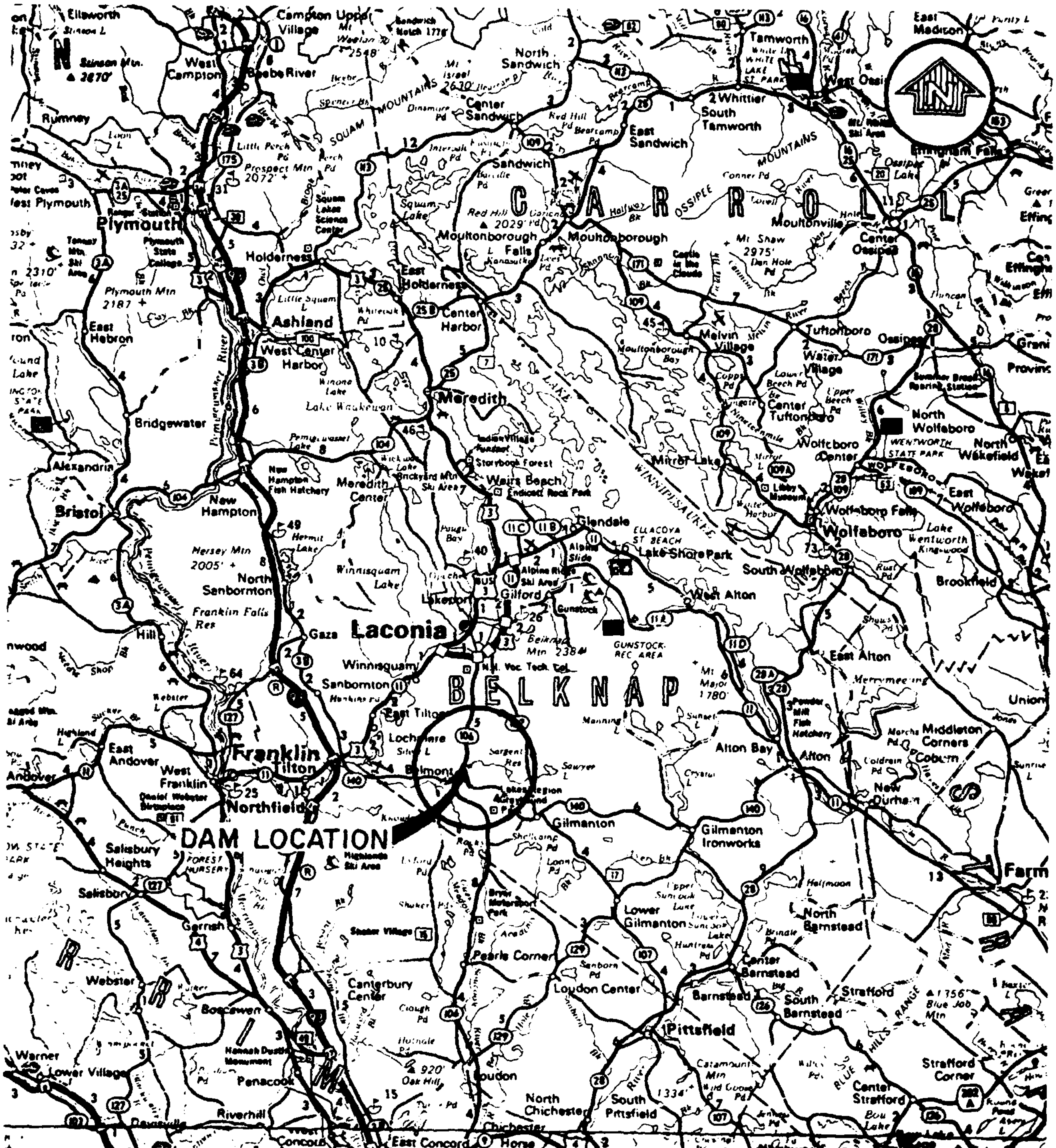
October 4, 1979
Figure 1 - Overview of Badger Pond Dam.



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SCALE IN MILES

0 5 10

MAP BASED ON STATE OF NEW HAMPSHIRE OFFICIAL HIGHWAY MAP.

Anderson-Nichols & Co., Inc.
CONCORD NEW HAMPSHIRE

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

BADGER POND DAM
LOCATION MAP

TIOGA RIVER NEW HAMPSHIRE

SCALE: SEE BAR SCALE

DATE: NOVEMBER 1979

NATIONAL DAM INSPECTION PROGRAM
PHASE 1 INSPECTION REPORT
BADGER POND DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Anderson-Nichols & Company, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to Anderson-Nichols under a letter of March 22, 1979 from John P. Chandler, Colonel, Corps of Engineers. Contract No. DACW33-79-C-0050, as changed, has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) To encourage and prepare the States to initiate quickly effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Badger Pond Dam is located in the Town of Belmont, New Hampshire. Badger Pond Dam impounds flow from Badger Brook and Tioga River. After discharging at the damsite, the water course is the Tioga River which flows southwesterly through Belmont, approximately one mile downstream, and continues downstream for a distance of 2,500 feet from Belmont proper to where Pumping Station Brook joins the Tioga River. It then shifts westerly and flows a distance of approximately 5 miles before emptying into the Winnipesaukee River about 0.2 mile northeast of the boundary intersection among the Towns of Belmont, Northfield and Tilton. The Winnipesaukee River is a

major tributary in the Merrimack River Basin. Badger Pond Dam is shown on U.S.G.S. Quadrangle, Gilmanton, New Hampshire, with coordinates approximately at N 43° 27' 6", W 71° 28' 10", Belknap County, New Hampshire. (See Location Map Page vii.)

b. Description of Dam and Appurtenances. Badger Pond Dam is a concrete capped, dry-stone-masonry spillway with concrete walled, rockfill and masonry abutments. The spillway is 120 feet long and 18 feet wide. The upstream abutment walls are vertical. Approximately 100 feet from the south end of the dam is the control mechanism for the south abutment low-level outlet. The south abutment area adjacent to the spillway measures 11 feet by 11 feet in plan and contains gearing mechanism for controlling the low-level outlet and a gear mechanism maintenance pit. The concrete capped masonry spillway measures 120 feet in total length and has a change in alignment at approximately 75 feet from the south abutment. The north abutment is a vertical concrete wall 2 feet in width and approximately 55 feet in length. Both the north and south abutments and the spillway have lower dry stone masonry walls downstream.

c. Size Classification. Small (hydraulic height - 21 feet; storage - 510 acre-feet) based on storage ($\geq$ 50 to $<$ 1000 acre-feet) as given in the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. High hazard. A major breach would probably result in the loss of 10 or more lives and extensive property damage. (See Section 5.1 f.)

e. Ownership. The earliest recorded information concerning Badger Pond Dam does not indicate when the original structure was built. Belmont Hosiery Company in Belmont, New Hampshire, owned the dam and in 1929 did major repair and reconstruction work to it. Ownership passed to James Locke of Campton, New Hampshire at an unknown date and passed again to the present owner, Pascoe Roberts, at an unknown date.

f. Purpose of Dam. The dam was originally constructed to provide industrial water storage for Belmont Hosiery Company for use in their milling operations in Belmont. The impoundment is presently used for conservation and recreation purposes.

g. Design and Construction History. Little information was disclosed regarding the original design and construction of Badger Pond Dam. Information recovered from NHWRB files revealed design plans and specifications dated 1929 covering "extensive repairs, practically amounting to reconstruction of the dam." These were drawn by I. W. Jones & Company of Milton, New Hampshire.

h. Normal Operating Procedures. No written operational procedures exist for Badger Pond Dam.

(1) The gate mechanism in the south abutment is rusted and does not appear to have been used for a number of years.

(2) The gate mechanism for the north abutment low-level outlet has been bent and is in disrepair.

1.3 Pertinent Data

a. Drainage Area. The drainage area consists of 16 square miles (10,240 acres) of mountainous to rolling forested terrain. The normal pool has a surface area of 20 acres, which constitutes 0.2 percent of the watershed. Sawyer and Sargent Lakes are also present in the upstream drainage area on Badger Brook.

b. Discharge at Damsite

(1) Outlet works (conduits): One 36" gated, riveted, steel pipe @ invert elevation 562' MSL. This pipe was assumed inoperable as the mechanism appeared rusted and unlubricated. One 2' x 2' gated, rock-walled low-level outlet@ invert elevation 564' MSL. This gate was assumed inoperable as the mechanism linkage was bent and rusted.

(2) The maximum discharge at damsite is unknown. No records of past overtoppings were disclosed.

(3) Ungated spillway capacity @ top of dam elevation - 4,760 cfs @ 583.0' MSL

(4) Ungated spillway capacity @ test flood elevation - 16,070 cfs @ 590.5' MSL

(5) Gated spillway capacity at top of dam elevation - not applicable

(6) Gated spillway capacity at test flood elevation - not applicable

(7) Total spillway capacity at test flood elevation - 16,070 cfs @ 590.5' MSL

(8) Total project discharge at test flood elevation - 30,500 cfs @ 590.5' MSL

c. Elevation (ft. above NGVD of 1929; formerly called Mean Sea Level (MSL); see (6) below.)

(1) Streambed at centerline of dam - 562 (downstream toe)

(2) Maximum tailwater - unknown

(3) Upstream portal invert diversion tunnel - not applicable

(4) Recreation pool - 577.0

(5) Full flood control pool - not applicable

(6) Spillway crest - 577.0 (obtained from U.S.G.S. (Quadrangle sheet and assumed to be spillway elevation)

(7) Design surcharge (original design) - unknown

(8) Top Dam - 583.0

(9) Test flood design surcharge - not applicable

d. Reservoir (miles)

(1) Length of maximum pool - 0.2

(2) Length of recreation pool - 0.2

(3) Length of flood control pool - not applicable

e. Storage (acre-feet)

(1) Recreation pool - 180

(2) Flood control pool - not applicable

(3) Spillway crest pool - 180

(4) Test flood pool - 960

(5) Top dam - 510

f. Reservoir Surface (acres)

(1) Recreation pool - 20

(2) Flood control pool - not applicable

(3) Spillway crest - 20

(4) Test flood pool - 65

(5) Top of dam - 51

g. Dam

(1) Type - concrete wall upstream, masonry wall downstream with rockfill

(2) Length - 260'

(3) Height - 21' structural height

(4) Top width - 18'

(5) Side Slopes - spillway upstream is vertical
- spillway downstream is approximately 2H:1V

(6) Zoning - unknwon

(7) Impervious core - unknown

(8) Cutoff - unknown

(9) Grout curtain - unknown

h. Diversion and Regulating Tunnel - not applicable (See j. below.)

i. Spillway

(1) Type - free overflow sloping spillway

(2) Length of weir - 120'

(3) Crest elevation - 577.0'

(4) Gates - none

(5) U/S Channel - Badger Pond. The banks are tree-lined.

(6) D/S Channel - Tioga River. Discharge from the dam flows southwesterly a distance of about one mile through Belmont proper and another 2,500 feet to where Pumping Station Brook joins. Three road bridge crossings exist between the dam and downstream of Belmont.

j. Regulating Outlets. One 36" steel pipe functioned as a low-level outlet. This outlet is in the south abutment. The pipe has an invert elevation at 562' and exits at the dam toe. Rusting parts and the lack of lubrication indicate this low-level outlet has not been in operation for a lengthy yet unknown period of time. One 2' x 2' rock-walled outlet in the north abutment was assumed to have formerly been used as a low-level outlet for the reservoir. The control mechanism linkage for this outlet was bent and in serious disrepair. This gate mechanism also appears inoperable.

SECTION 2
ENGINEERING DATA

2.1 Design

No original design data were disclosed for Badger Pond Dam.

2.2 Construction

No original construction records were disclosed.

2.3 Operation

No engineering operational data were disclosed.

2.4 Evaluation

a. Availability. Little engineering data were disclosed for Badger Pond Dam. A search of the files of the New Hampshire Water Resources Board (NHWRB) revealed only a limited amount of recorded information. Correspondence with the owner by several methods proved unsuccessful. Therefore, it is possible that additional information on the dam may exist.

b. Adequacy. The final assessments and recommendations of this investigation are based on visual inspection and the hydrologic and hydraulic calculations.

c. Validity. Plans drawn by I. W. Jones Engineers of Milton, New Hampshire in 1929 for the reconstruction of Badger Pond Dam are generally consistent with the visual inspection.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. Badger Pond Dam is a low dam which impounds a reservoir of small size. The watershed above the reservoir is rolling to steeply sloping and is heavily wooded. The Town of Belmont is about 0.7 mile downstream from the dam.

b. Dam. Badger Pond Dam is 21 feet high (hydraulic and structural height) and 260 feet long. (See Appendix C - Figure 2.) The central part of the dam is a concrete capped, stone masonry spillway section 120 feet long with a sloping spillway apron 18 feet wide inclined at approximately 2H:1V. The downstream edge of the spillway section is a dry masonry wall which is vertical in its lower part and curves over to meet the slope of the concrete apron in its upper part. (See Appendix C - Figure 3.) The upstream face of the spillway section, where it can be seen above the pond level, is faced with concrete. The surface of the concrete spillway is eroded exposing the coarse aggregate. (See Appendix C - Figure 4.) Two isolated areas on the sloped surface have spalled up to a depth of 2 inches. The concrete edges of the construction joints are eroded deeper than the inclined surface creating a "v" approximately 1 inch deep at each construction joint. Vertical training walls at either end of the spillway are undermined 3 to 4 inches where the walls have been in constant contact with water. (See Appendix C - Figure 5.) Some small brush is growing in the joints near the center of the concrete spillway. Steel stoplog supports in the crest are rusted and some are filled with silt. (See Appendix C - Figure 5.) The stoplog slots in the training walls are eroded near the crest of the spillway. From the north end of the spillway to the north abutment the dam consists of a concrete wall 54 feet long and 2 feet wide at the crest with a vertical upstream face inclined at approximately 2H:1V buttressed with rockfill against the downstream face. (See Appendix C - Figure 6.) Hairline cracks in both faces show efflorescence and are numerous. A concrete retaining wall on the upstream face retains the earth embankment at the north end of the north non-overflow gravity section. (See Appendix C - Figure 7.) Separation of the construction joint between the retaining wall and the gravity wall indicates that the retaining wall has moved laterally approximately 1 inch. The upstream face of the wall has a horizontal area of spalling and erosion to a maximum depth of 4 inches. A low-level outlet near the left end of the north spillway abutment was observed. (See Appendix C - Figure 8.) The gate operating mechanism has not been maintained and the vertical shaft below the operator is bent. (See Appendix C - Figure 9.) The gate operating mechanism does not appear operable.

The downstream exit of this outlet is an opening, 2 feet wide by 2 feet high, in the rockfill buttress. (See Appendix C - Figure 8.) Loose rockfill plugs the opening over approximately half its total height. Rust staining of the ground surface near the contact between the rockfill buttress and the north abutment indicates that seepage has discharged from that area at some time in the recent past; however, no water was discharging at the time of inspection. Many small trees are growing in the rockfill buttress and larger trees are growing immediately downstream of the toe of the rockfill buttress.

At the south abutment there is a vertical wall 2 feet wide at the upstream face of a short embankment section about 60 feet long and 11 feet wide at the crest. This wall has a vertical face upstream and a downstream face inclined at 1H:2V buttressed with a rockfill up to 5 feet below the crest at the downstream face. (See Appendix C - Figure 10.) Numerous hairline cracks on the downstream face are exhibiting efflorescence. A concrete, gated outlet structure was observed at the right end of the south abutment. The outlet consists of a 36-inch diameter steel pipe which is encased in a concrete headwall at its downstream end. (See Appendix C - Figure 11.) Large rocks have been thrown or placed in this pipe.
(See Appendix C - Figure 12.)

A short section of earth embankment exists between the end of the vertical wall and the south abutment. No vegetation was growing on the crest of this embankment probably because of trespassing. Trees are growing on the upstream and downstream slopes of the embankment and on the natural ground near the downstream toe of the embankment.

c. Appurtenant Structures. A concrete control tower housing the gated outlet structure is integrated with the vertical concrete wall at the south abutment and adjacent to the south end of the spillway. (See Appendix C - Figure 13.) The concrete tower measures 11 feet wide by 11 feet long and supports a gate operating mechanism. A 2-foot by 2-foot gear mechanism maintenance pit allows access down to the low-level outlet. Flashboard slots were observed on the side of the concrete tower adjacent to the spillway. Holes along the spillway crest used to accommodate flashboard pins were observed, however, no pins were in place. No flashboards were in place at the time of inspection. The gate operating mechanism appears to be in fair condition, however, it is not lubricated. The gate appears not to have been operating for several years. The 36-inch diameter steel pipe on the downstream end is severely corroded. The downstream face of the control tower has numerous hairline cracks exhibiting efflorescence. (See Appendix C - Figure 11.) A portion of the concrete face immediately above the steel pipe is eroded to a depth of approximately 3 inches. Other areas around the pipe down to the tailwater surface are also eroded.

d. Reservoir Area. The watershed above the pond is gently to steeply sloping and heavily wooded. No buildings were observed on the shore of the reservoir. (See Appendix C - Figure 14.) No evidence of significant sedimentation in the reservoir was observed.

e. Downstream Channel. The bottom of the channel downstream of the dam is covered with boulders. Trees and brush overhang the channel and are growing in the channel in some places. (See Appendix C - Figure 15.)

3.2 Evaluation

Based on the visual inspection, Badger Pond Dam is in fair condition. Evidence that seepage has occurred in the recent past at the contact between the dam and the north abutment was observed (although no seepage was discharging at the time of the inspection). Such seepage could lead to a future stability problem if not corrected.

Trees are growing on the upstream and downstream slopes of the embankment section at the south end of the dam, in the rockfill buttress at the north end of the dam, and near the downstream toe of the dam. If a tree blows over and its roots are pulled out or if a tree dies and its roots rot, seepage and erosion problems may result. The lack of vegetation on the crest of the embankment section at the south end of the dam results in low erosion resistance if the dam should be overtopped.

The concrete surface of the spillway, non-overflow section, and control tower are deteriorated and could lead to future instability if left uncorrected.

Trees overhanging the discharge channel may blow or drop over into the channel as a result of erosion during periods of high discharge at the damsite. These trees may obstruct flow in the channel and in the culverts downstream.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

No written maintenance procedures exist for Badger Pond Dam. The lake level is maintained by the uncontrolled spillway located near the center of the dam.

4.2 Maintenance of Dam

Mr. Pascoe Roberts, the owner, is responsible for the maintenance of the dam.

4.3 Maintenance of Operating Facilities

No formal maintenance was disclosed. The low-level outlet mechanisms are deteriorated. The operation of the low-level outlet mechanisms was not observed during the visual inspection. The stem handle for operating the north low-level outlet was in poor condition and appeared inoperable. The gate operating mechanism for operating the south low-level outlet was in fair condition.

4.4 Description of Any Warning System in Effect

No written warning system exists for the dam.

4.5 Evaluation

The present operational and maintenance procedures are inadequate to ensure that all problems encountered could be remedied within a reasonable amount of time.

SECTION 5
HYDROLOGIC/HYDRAULIC

5.1 Evaluation of Features

a. General. Badger Pond Dam is a rockfill embankment contained between concrete and masonry walls. The total length of the dam is 260 feet. The principal spillway is concrete capped dry-stone masonry. The spillway is uncontrolled and its total length is 120 feet with a change of alignment at about 75 feet from the south abutment. The reservoir level is controlled by the principal spillway. The low-level outlet mechanisms on the north and south abutments appeared to be inoperable. The drainage area consists of 16 square miles of mountainous terrain. Sawyer and Sargent Lakes are present in the upstream watershed. Discharge at the damsite forms the Tioga River.

b. Design Data. No hydrologic or hydraulic design data were disclosed.

c. Experience Data. The known flood of record occurred in 1936. In 1938, the earthen embankment at Sargent Lake Dam was breached upstream of Badger Pond Dam. The resulting flood wave passed over Badger Pond Dam and inundated State Route 106 to a depth of 2 feet just downstream.

d. Visual Observations. At the time of inspection, no visual evidence was noted of damage to the dam caused by excessive discharge.

e. Test Flood Analysis. Badger Pond Dam is classified as small in size having a hydraulic height of 21 feet and a maximum storage capacity of 510 acre-feet; the dam was determined to have a High Hazard Classification. Using the Recommended Guidelines for Safety Inspection of Dams, the test flood ranges from ½ to the Probable Maximum Flood (PMF). Because of the potential for loss of life in event of a breach, the PMF was selected as the test flood.

The test flood inflow for Badger Pond Dam combines two values. The PMF combines the outflow from Sargent Lake Dam plus the additional discharge from the Badger Pond Dam sub-drainage area. The outflow from Sargent Lake Dam, having a drainage area of 2.8 square miles, was determined to be 5,850 cfs. The additional discharge from the Badger Pond Dam sub-drainage area, having an area of 13.2 square miles, using the 'mountainous' guide curves, was determined to be 25,080 cfs. The total test flood inflow was 30,930 cfs (1933 csm). After routing, the test flood outflow was determined to be 30,500 cfs (1906 csm) at elevation 590.5' MSL, reflecting negligible surcharge storage effects on reducing peak runoff. The test flood analysis indicates that the dam embankment would be overtopped by approximately 7.5 feet during test flood conditions. The spillway capacity at top of dam is 4,760 cfs or 16 percent of the test flood. Assuming ½ PMF discharge was 15,250 cfs, the dam would be overtopped by 4.3 feet at elevation 587.3' MSL.

f. Dam Failure Analysis. The impact of failure of the dam at both spillway (normal flow conditions) and at top of dam was assessed using the Guidance for Estimating Downstream Dam Failure Hydrographs issued by the Corps of Engineers. A breach at spillway crest would produce the greater downstream hazard and, therefore, was used in evaluating the hazard classification for Badger Pond Dam. A breach of Badger Pond Dam at spillway crest would result in a breach discharge of 4,880 cfs and result in the following stages in the downstream reaches and bridges. The antecedent condition is 0.5 foot at the reach sections and bridges.

Reach #1: From Badger Pond Dam to State Route 106 an increase in stage of 9.5 feet over the 0.5 foot antecedent condition would result. There would be no property damage.

At State Route 106 an increase in stage of 11.1 feet over the 0.5 foot antecedent condition would result. One private residence along State Route 106 would be inundated. The structure consists of a 6'H x 30' W box culvert. The road would be overtopped by 2 feet.

Reach #2: From State Route 106 to Hurricane Road an increase in stage of 10.5 feet over the 0.5 foot antecedent condition would result. There would be no property damage.

At Hurricane Road an increase in stage of 12.5 feet over the 0.5 foot antecedent condition would result. Three private residences, one laundry and one church adjacent to the Hurricane Road culvert would be inundated. Loss of 10 or more lives in this reach could occur. The culvert consists of a corrugated metal pipe arch with a span of 18.5 feet, and a rise of 12.5 feet. The road would be overtopped by 2.5 feet.

Reach #3: From Hurricane Road to the State Route 140 an increase in stage of 8.0 feet over the 0.5 foot antecedent condition would result. There would be no property damage.

At State Route 140 an increase in stage of 6.3 feet over the 0.5 foot antecedent condition would result. One mobile home adjacent to State Route 140 would be inundated. Loss of 3 lives in this reach could occur. The State Route 140 structure consists of a 12' H x 32' W box culvert. The road would not be overtopped.

Based on the above analysis, Badger Pond Dam was classified High Hazard.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. The visual examination indicates the following evidence of potential problems:

(1) Signs that seepage has occurred in the recent past near the contact between the downstream rockfill buttress and the north abutment.

(2) Trees growing on the upstream and downstream slopes of the embankment section at the south end of the dam, in the rockfill buttress at the north end of the dam, and near the downstream toe of the dam at both the north and south ends of the dam.

(3) Lack of vegetation and, therefore, erosion protection on the crest of the embankment section at the south end of the dam.

(4) Deteriorated areas of concrete on the spillway, non-overflow sections and control tower.

In addition, the low-level outlets are partially blocked, and trees and brush overhang the discharge channel and are growing in the channel in some places.

b. Design and Construction Data. No original design and construction data are available.

c. Operating Records. No operating records pertinent to the structural stability of the dam are available.

d. Post-Construction Changes. A New Hampshire Water Resources Board inventory report dated July 17, 1934, indicates that the dam was "rebuilt." No other record of post-construction changes is available.

e. Seismic Stability. This dam is in Seismic Zone 2 and in accordance with the Phase I guidelines does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination indicates that Badger Pond Dam is in fair condition. The major concerns with respect to the long-term integrity of the dam are:

(1) Signs that seepage has occurred in the recent past near the contact between the downstream rockfill buttress and the north abutment.

(2) Trees growing on the upstream and downstream slopes of the embankment section at the south end of the dam, in the rockfill buttress at the north end of the dam, and near the downstream toe of the dam at both the north and south ends of the dam.

(3) Lack of vegetation on the crest of the embankment section at the south end of the dam.

(4) Deteriorated areas of concrete on the spillway, non-overflow section and control tower.

b. Adequacy of Information. The information available is such that the assessment of this dam must be based primarily on the results of the visual inspection.

c. Urgency. The recommendations made in 7.2 and 7.3 should be implemented by the owner within one year after receipt of this Phase I report.

d. Need for Additional Investigation. The area immediately downstream of the toe of the dam should be inspected after the trees and brush have been cleared.

7.2 Recommendations. The owner should engage a Registered Professional Engineer to:

(1) Investigate the recent seepage at the north abutment of the dam and design corrective measures, if needed.

(2) Design procedures for clearing trees and brush from the embankment section of the dam, the downstream-toe area, and the rockfill buttress at the north end of the dam.

(3) Design repairs to the deteriorated concrete.

(4) Evaluate further the stability of the dam under overtopping because of the inadequate spillway.

(5) Design repairs to the low-level outlet gate and discharge pipe.

(6) Monitor crack in gravity wall.

The owner should carry out the recommendations of the engineer.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. The owner should:

(1) Establish grassy vegetation, or other erosion-resistant protection, on the crest of the embankment section at the south end of the dam.

(2) Maintain the area within 25 feet downstream from the toe of the dam free of trees and brush.

(3) Remove trees and brush from the downstream channel and for a distance of 25 feet on either side of the channel for a distance of 100 feet downstream of the dam or to limits of property whichever is the lesser distance.

(4) Clear the partial blockage of the 36" low-level outlet.

(5) Visually inspect the dam and appurtenant structures once a month.

(6) Engage a Registered Professional Engineer to make a comprehensive inspection of the dam once a year.

(7) Establish a surveillance program for use during and immediately after heavy rainfall and also a warning program to follow in case of emergency conditions.

7.4 Alternatives

No alternatives are recommended.

APPENDIX A

VISUAL INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT Badger Pond Dam, NH

DATE Sept. 7, 1979

TIME 1400

WEATHER Sunny, hot

W.S. ELEV. U.S. 577.1 DN.S. 562.0

PARTY:

1. Stephen Gilman (ANCo)
2. Gus Sharry (ANCo)
3. Ken Stuart (ANCo)
4. Mehdi Miremadi (ANCo)
5. Ronald Hirschfeld (GEI)
6. Ken Stern (NHWRB)
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Hydrology/Hydraulics	A. Sharry/K. Stuart	
2.	Structural Stability	S. Gilman	
3.	Soils & Geology	R. Hirschfeld	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECKLIST

PROJECT Badger Pond Dam, NH DATE Sept. 7, 1979

PROJECT FEATURE Dike Embankment NAME R. Hirschfeld

DISCIPLINE _____ NAME S. Gilman

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	Short section between south abutment and left end of concrete and stone masonry dam
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	None observed
Pavement Condition	Not paved
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	None observed
Sloughing or Erosion of Slopes or Abutments	None observed
Rock Slope Protection - Riprap Failures	None observed
Unusual Movement or Cracking at or Near Toes	None observed
Unusual Embankment or Downstream Seepage	None observed
Piping or Boils	None observed
Foundation Drainage Features	None observed
Toe Drains	None observed
Instrumentation System	None observed
Vegetation	Trees and brush growing on upstream and downstream slopes

PERIODIC INSPECTION CHECKLIST

PROJECT Badger Pond Dam, NH DATE Sept. 7, 1979

PROJECT FEATURE Outlet Works - Intake Structure NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	
Slope Conditions	Not applicable
Bottom Conditions	Not visible beneath lake surface
Rock Slides or Falls	None
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	None
b. Intake Structure	
Condition of Concrete	
Stop Logs and Slots	2 inches wide, 3 feet deep eroded near crest of spillway
Stoplog Support Holes in Crest	Rusted and some holes filled with silt

PERIODIC INSPECTION CHECKLIST

PROJECT Badger Pond Dam, NH DATE Sept. 7, 1979

PROJECT FEATURE Control Tower NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	
General Condition	Fair
Condition of Joints	No indication of movement
Spalling	Several isolated spots up to 3" deep
Visible Reinforcing	Only at one spall
Rusting or Staining of Concrete	Rusting only at imbedded items
Any Seepage or Efflorescence	Several areas on downstream face show wet effloresced areas
Joint Alignment	No indication of movement
Unusual Seepage or Leaks in Gate Chamber	None visible
Cracks	Numerous hairline cracks in downstream face where efflorescing visible
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	North abutment gate in poor condition; gate inoperable due to bent shaft and spring rack gear
Emergency Gates	South abutment gate in fair condition; gate mechanism has no operating handle and mechanism is badly rusted
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECKLIST

PROJECT Badger Pond Dam, NH DATE Sept. 7, 1979

PROJECT FEATURE Outlet Works - Spillway Weir and Discharge Channel NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	Fair - surface eroded with loss of surface laitance
Rust or Staining	None visible
Spalling	Two isolated areas where sloped face is spalled up to 2"
Any Visible Reinforcing	None
Any Seepage or Effloresceonce	None visible on weir - several areas on end training walls
Drain Holes	None visible
c. Discharge Channel	
General Condition	Right training wall - surface erosion where in contact with water. Base of wall undermined 3" - 4"
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

PROJECT Badger Pond Dam, NH

DATE Sept. 7, 1979

PROJECT FEATURE Reservoir

NAME K. Stuart

AREA EVALUATED	REMARKS
Stability of Shoreline	Good
Sedimentation	Not visible
Changes in Watershed Runoff Potential	None
Upstream Hazards	None
Downstream Hazards	State Route 106, Hurricane Road, Belmont proper, State Route 140
Alert Facilities	None posted
Hydrometeorological Gages	None
Operational & Maintenance Regulations	None posted

APPENDIX B

ENGINEERING DATA

M E M O

Held for C.E. Report

Date: September 10, 1979

To: Vernon A. Knowlton,
Chief Engineer

From: Ken Stern,
Water Resources Engineer

Subject: Badger Pond, No. 21.02, Belmont

On September 7, 1979 I accompanied the Anderson-Nichols' inspection team.

The dam appears to be in good to fair condition. The dam appears stable but the original concrete workmanship was fair. Considering the fair starting condition the concrete has done reasonably well. The left abutment gate structure has one cold joint which has spalled and an area of efflourescence and spalling.

Vandals have partially blocked the outlet penstock at the left abutment with stones. These should not affect the pond drain function of this gate.

The old gate in the right abutment is inoperable. There is very minor seepage through it. There is an area downstream of the right stone and concrete retaining wall which is wet and rust colored. This area may be seepage or groundwater. There was no flow at the time of inspection.

The right earth dike is overgrown with trees. There are some trees growing near the stonework of the whole structure.

The extreme right retaining wall is in fair to poor condition. It has leaned towards the impoundment opening a one inch joint at the construction joint at the juncture with the gravity section abutment wall. The extreme right wall is also spalled at the water line.

Rusted flashboard pins 2 1/2" in diameter were found at the downstream toe.

The dam appears to be stable and our action can wait until the report is received.

KS:paf

Ken

NEW HAMPSHIRE WATER RESOURCES BOARD

INSPECTION REPORT

Town: Belmont Dam Number: 21.02

Name of Dam, Stream and/or Water Body: [illegible] Pond

Owner: ~~[illegible]~~ SOLD TO PASCOE ROBERTS OF [illegible] Telephone Number: 726-8988

Mailing Address: ~~[illegible]~~ [illegible], Canterbury NH 03224

Max. Height of Dam: 19 ft Pond Area: [illegible] Length of Dam: 150'

FOUNDATION: Concrete

OUTLET WORKS: overflow spillway and gate section.
3' ϕ [illegible] Pond [illegible] 1.5 x 1.5'

ABUTMENTS: Concrete
One minor crack at the rt abutment

EMBANKMENT: Earth

Note: Give Sizing, Condition and detailed description for each item, if applicable.

Dam NO. _____

SPILLWAY: Length: 45' Freeboard: 4.5 ft

SEEPAGE: Location, estimated quantity, etc.

None

Changes Since Construction or Last Inspection:

None

Tail Water Conditions:

Fair Free flow

Overall Condition of Dam: Good

Contact With Owner: No

Date of Inspection: 5/24/78 Suggested Reinspection Date 1979

Class of Dam: Menace

Signature John D Lawson

Date 5/24/78

Note: Give Sizing, Condition and detailed description for each item, if applicable.

Dam No. _____

COMMENTS:

1) Some erosion of concrete and a crack at right abutment to be repaired.

From Right Abutment
5.2+/-8'

State of New Hampshire
WATER RESOURCES BOARD
37 [illegible]
Concord, N.H. [illegible]
TELEPHONE [illegible]

May 25, 1978

Mr. James Locke
Drawer E
Campton, New Hampshire 03228

Dear Sir:

Under the provisions of RSA Chapter 482, Sections 8 through 15, copy enclosed, on May 24, 1978, an engineer of the Water Resources Board inspected your dam in Belmont. This Dam, No. 21.02, is classified in the files of this Office as a menace structure and as such must be maintained in a manner not to endanger public safety nor become a dam in disrepair.

As a result of this inspection it was noted that an item of maintenance was in need of attention:

Some erosion of concrete and a crack at right abutment to be repaired.

Because this dam is classified as a menace structure, we require that you send us a proposed schedule of repairs. The actual work does not have to begin until the weather is better, but we need this schedule within thirty (30) days.

If you have any questions, please contact us at your convenience.

Sincerely,

George McGee Sr.

GMM:paf
Enc.

George M. McGee, Sr.,
Chairman

RECEIPT FOR CERTIFIED MAIL—30¢ (plus postage)

SENT TO

STREET AND NO.

P.O. STATE AND ZIP CODE

POSTMARK OR DATE

OPTIONAL SERVICES FOR ADDITIONAL FEES

RETURN RECEIPT SERVICES
1. Shows to whom and date delivered 15¢
With delivery to addressee only 65¢
2. Shows to whom, date and where delivered 35¢
With delivery to addressee only 85¢

DELIVER TO ADDRESSEE ONLY 50¢

SPECIAL DELIVERY (extra fee required)

PS Form 3800 Apr. 1971

NO INSURANCE COVERAGE PROVIDED—NOT FOR INTERNATIONAL MAIL

(See other side)

GPO 1972 O - 460-743

No. 14-023

y 27, 1976

Mr. Pascoe Roberts
Main Street
Compton, N. H. 03223

Dear Mr. Roberts:

Under the provisions of RSA Chapter 482, Sections 8 through 15, copy enclosed, on October 3, 1974, an engineer of the Water Resources Board inspected your dam on Badger Pond in Belmont. This Dam #21.02 is classified in the files of this office as a menace structure and as such must be maintained in a manner not to endanger public safety nor become a dam in disrepair.

As a result of this inspection it was noted that some of the concrete on the left side (as looking downstream) of the spillway is eroded. This shall be repaired to protect the safety of the structure.

Because this structure is classified as a menace structure, we require that you send us a proposed schedule of repairs within thirty (30) days. This work should be started as soon as weather permits.

If you have any questions, please contact us at your convenience.

Very truly yours,

George M. McGee, Sr.
Chairman

GMM/SCB:L

Enc.

cc: Board of Selectmen
Belmont N H

N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

Town: Belmont Dam Number: 21.02

Inspected by: SCS Date: 30 Oct 1974

Local name of dam or water body: _____

Owner: _____ Address: _____

Owner was/(was not) interviewed during inspection.

Drainage Area: _____ sq. mi. Stream: _____

Pond Area: _____ Acre, Storage _____ Ac-Ft. Max. Head _____ Ft.

Foundation: Type _____, Seepage present at toe - Yes/(No),

Spillway: Type Overflow, Freeboard over perm. crest: _____,

Width _____, Flashboard height _____,

Max. Capacity _____ c.f.s.

Embankment: Type _____, Cover _____ Width _____,

Upstream slope _____ to 1; Downstream slope _____ to 1

Abutments: Type Concrete, Condition: (Good), Fair, Poor

Gates or Pond Drain: Size 3' dia Capacity _____ Type Rodney Hunt Type 3012

Lifting apparatus _____ Operational condition ?

Pond Drain 1.5'x1.5' " No

Changes since construction or last inspection: _____

Downstream development: _____

This dam (would)/would not be a menace if it failed.

Suggested reinspection date: _____

Remarks: Some Concrete erosion on spillway

Cond Good

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE

LOCATION STATE NO. 21.02

Town Belmont : County Sul

Stream Lower Pond

Basin-Primary Merrimack R. : Secondary [illegible]

Local Name Badger Pond

Coordinates—Lat. 43° 25' + 13000' : Long. 71° 25' + 14000'

GENERAL DATA

Drainage area: Controlled ..... Sq. Mi.: Uncontrolled ..... Sq. Mi.: Total 15.1 Sq. Mi.

Overall length of dam 263.6 ft.: Date of Construction .....

Height: Stream bed to highest elev. 19 ft.: Max. Structure 19' ft.

Cost—Dam .....: Reservoir .....

DESCRIPTION

Waste Gates

Type .....

Number 1 : Size 1.5 ft. high x 1.5 ft. wide

Elevation Invert .....: Total Area 2.25 sq. ft.

Hoist .....

Waste Gates Conduit

Number .....: Materials .....

Size ..... ft.: Length ..... ft.: Area ..... sq. ft.

Embankment

Type .....

Height—Max. ..... ft.: Min. ..... ft.

Top—Width .....: Elev. ..... ft.

Slopes—Upstream ..... on .....: Downstream ..... on .....

Length—Right of Spillway .....: Left of Spillway .....

Spillway

Materials of Construction .....

Length—Total 45' ft.: Net ..... ft.

Height of permanent section—Max. 16' ft.: Min. ..... ft.

Flashboards—Type .....: Height ..... ft.

Elevation—Permanent Crest .....: Top of Flashboard .....

Flood Capacity ..... cfs.: ..... cfs/sq. mi.

Abutments

Materials: .....

Freeboard: Max. 3' ft.: Min. ..... ft.

Headworks to Power Devel.—(See "Data on Power Development")

OWNER Belmont-Harvey Co.

REMARKS

Tabulation By ..... Date .....

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE

LOCATION STATE NO. 21.03

Town Belmont : County Belknap

Stream Tioga River

Basin-Primary Merrimack R. : Secondary Winnepesaukee RR

Local Name Badger Reservoir

Coordinates—Lat. 43 25' + 13,000 : Long. 71 25' + 14,000

GENERAL DATA

Drainage area: Controlled ..... Sq. Mi.: Uncontrolled ..... Sq. Mi.: Total 15.99 Sq. Mi.

Overall length of dam 263.6 ft.: Date of Construction 1934

Height: Stream bed to highest elev. 18.65 ft.: Max. Structure 12.82 ft.

Cost—Dam ..... : Reservoir .....

DESCRIPTION Rock fill concrete face

Waste Gates

Type .....

Number 1 : Size 1.5 ft. high x 1 ft. wide

Elevation Invert ..... : Total Area 2.25 sq. ft.

Hoist .....

Waste Gates Conduit

Number ..... : Materials .....

Size ..... ft.: Length ..... ft.: Area ..... sq. ft.

Embankment

Type .....

Height—Max. ..... ft.: Min. ..... ft.

Top—Width ..... : Elev. ..... ft.

Slopes—Upstream ..... on ..... : Downstream ..... on .....

Length—Right of Spillway ..... : Left of Spillway .....

Spillway

Materials of Construction Timber

Length—Total ..... ft.: Net 45 ft.

Height of permanent section—Max. 14.58 ft.: Min. ..... ft.

Flashboards—Type ..... : Height 3' ft.

Elevation—Permanent Crest 732 : Top of Flashboard .....

Flood Capacity ~~655~~ 820 cfs.: 51.2 51.2 cfs/sq. mi.

Abutments

Materials: .....

Freeboard: Max. ..... ft.: Min. 3 ft.

Headworks to Power Devel.—(See "Data on Power Development")

OWNER Belmont Hoisiery Co. Belmont N.H.

REMARKS Menace if in disrepair

Tabulation By C.F.O. Date July 26, 1939

RAB2:284

7205

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON RESERVOIRS & PONDS IN NEW HAMPSHIRE

LOCATION AT DAM NO. 21.02

Town Belmont : County Belknap

Stream Tioga River

Basin—Primary Merrimack R. : Secondary ~~Belmont R.~~ Winnipesaukee R.

Local Name

DRAINAGE AREA

Controlled ..... Sq. Mi.: Uncontrolled ..... Sq. Mi.: Total 15.99 ~~15.99~~ Sq. Mi.

ELEVATION vs. WATER SURFACE AREA vs. VOLUME

Point	Head Feet	Surface Area Acres	Volume Acre Ft.
(1) Max. Flood Height			
(2) Top of Flashboards			
(3) Permanent Crest		14	179.5 ~~79.5~~
(4) Normal Drawdown			
(5) Max. Drawdown			
(6) Original Pond	600 USGS		

Base Used .....: Coef. to change to U.S.G.S. Base

RESERVOIR CAPACITY

	Total Volume	Useable Volume
Drawdown	ft.	ft.
Volume	ac. ft.	ac. ft.
Acre ft. per sq. mi.		
Inches per sq. mi.		

USE OF WATER Conservation

OWNER Belmont Mills Belmont N.H. ~~Hosiery Co.~~ Hosiery Co. ~~& N.H.~~

REMARKS

Tabulation By C.F.O. Date 7/26/39

NEW HAMPSHIRE WATER RESOURCES BOARD

INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM

BASIN Merrimack NO. 2 - 253 I-3.14 / [illegible]
RIVER Tioga MILES FROM MOUTH D.A.SQ.MI [illegible]
TOWN Belmont OWNER Belmont Hosiery Co [illegible]
LOCAL NAME OF DAM Badger Reservoir
BUILT 1850 DESCRIPTION Log Crib - Timber filled with stone on ledge & hardpan

POND AREA-ACRES 75 POND CAPACITY-ACRE FT.
HEIGHT-TOP TO BED OF STREAM-FT. 19 MAX MIN.
OVERALL LENGTH OF DAM-FT. 150 HEIGHT ABOVE CREST-FT.
PERMANENT CREST ELEV. U.S.G.S. LOCAL GAGE
TAILWATER ELEV. U.S.G.S. LOCAL GAGE
SPILLWAY LENGTHS-FT. [illegible] FREEBOARD-FT. [illegible] 4.3 [illegible]
FLASHBOARDS - TYPE, HEIGHT ABOVE CREST
WASTE GATES-NO. WIDTH MAX. OPENING DEPTH SILL BELOW CREST — Assume C = 3.3

WASTE GATES-NO.	WIDTH	MAX. OPENING	DEPTH SILL BELOW CREST
1	45	1.5	

REMARKS Information from questionnaire filed with P.S. Comm
BH Into Belmont R. [illegible] R.

POWER DEVELOPMENT

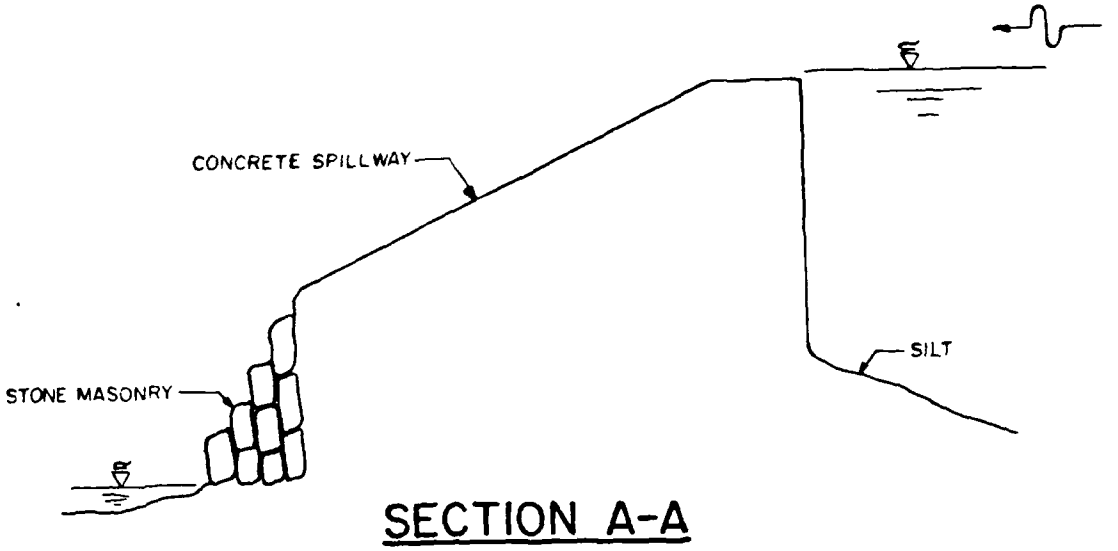
UNITS	NO.	RATED HP	HEAD FEET	C.F.S. FULL GATE	KW	MAKE

USE Conservation

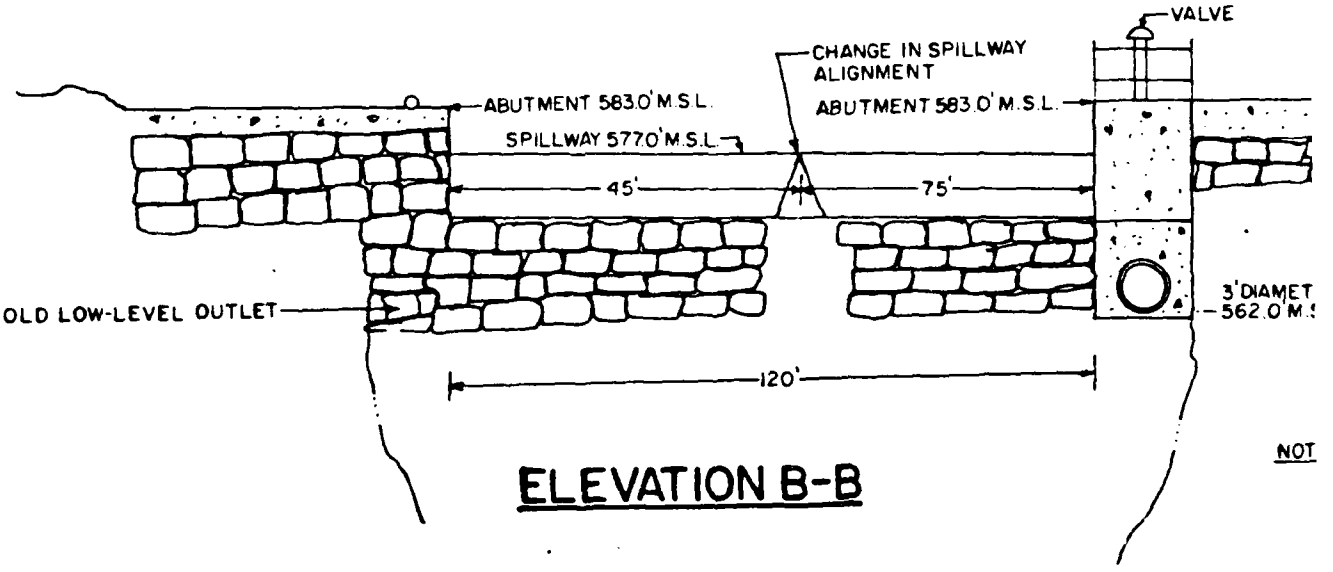
REMARKS Height was raised 5 ft Nov. 1934 to Apr. 35
2 miles from [illegible] would be Sargeant
[illegible] on Badger Bk

These [illegible] probably [illegible]

DATE

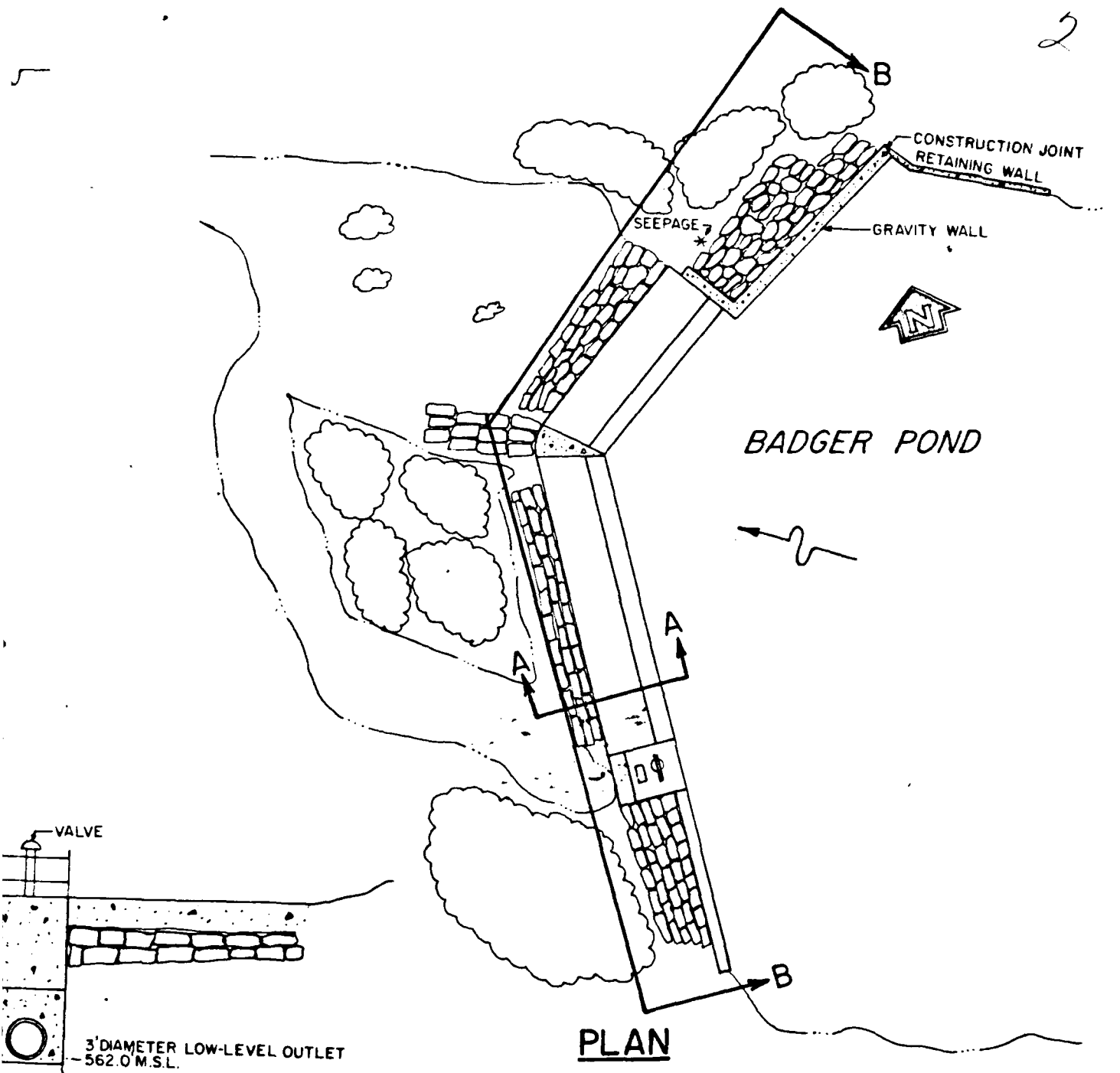


SECTION A-A



ELEVATION B-B

NOT



PLAN

NOTE ALL ELEVATIONS ARE RELATIVE TO ASSUMED SPILLWAY CREST 577.0' M.S.L. (N.G.V.D.)

Anderson-Nichols & Co., Inc CONCORD NEW HAMPSHIRE	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

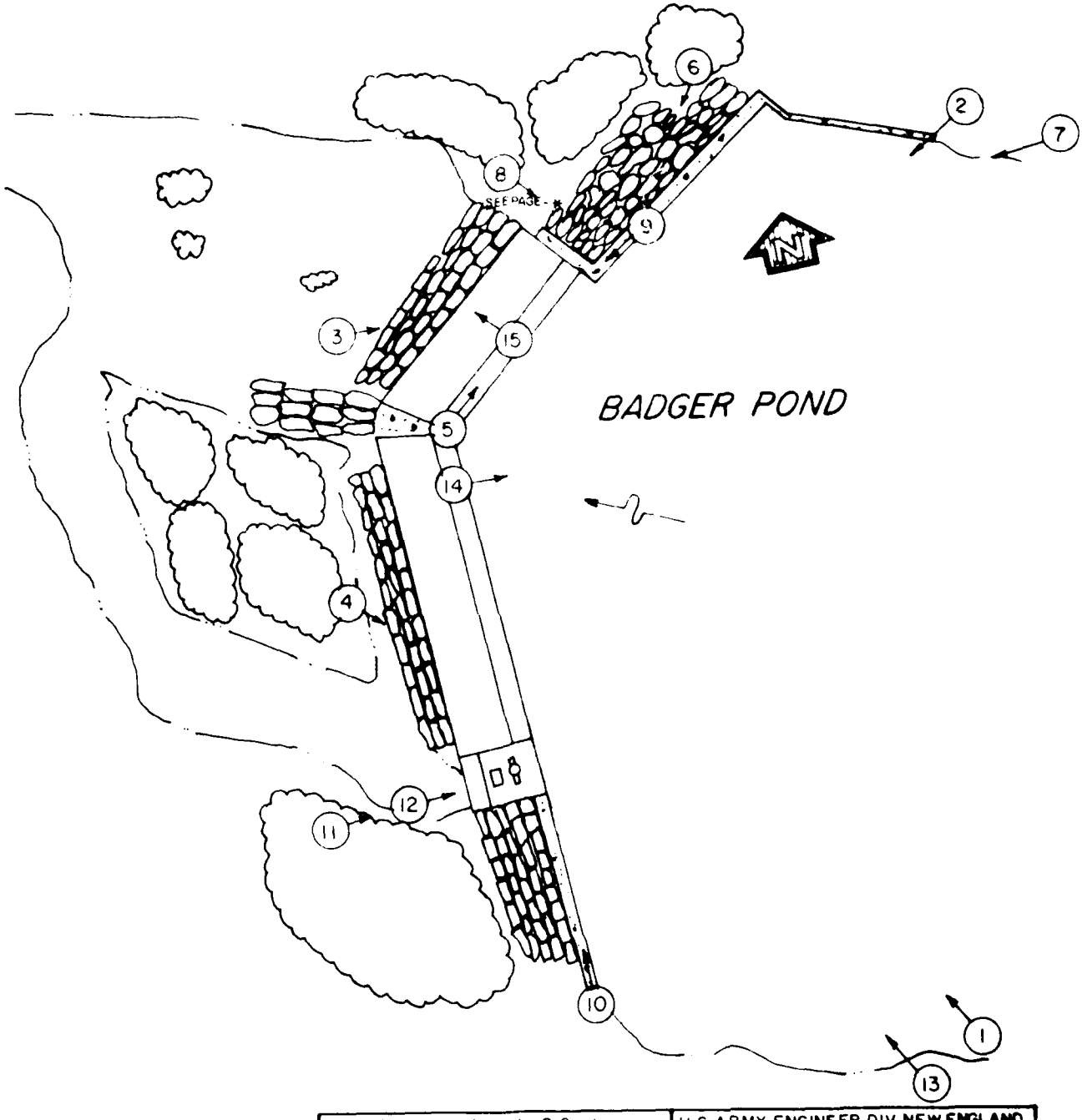
BADGER POND DAM

TIOGA RIVER NEW HAMPSHIRE

SCALE	NOT TO SCALE
DATE	NOVEMBER 1979

APPENDIX C

PHOTOGRAPHS



Anderson - Nichols & Co., Inc CONCORD NEW HAMPSHIRE	U S ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

PHOTO INDEX

TIOGA RIVER NEW HAMPSHIRE

			SCALE: NOT TO SCALE
			DATE: NOVEMBER 1979

September 7, 1979

Figure 2 - Looking at upstream face of dam from north abutment.

September 7, 1979

Figure 3 - View of downstream edge of spillway section.

September 7, 1979
Figure 4 - Looking at the concrete spillway and south abutment.

September 7, 1979
Figure 5 - View of north abutment vertical training wall.

September 7, 1979
Figure 6 - View showing downstream face of north abutment.

September 7, 1979
Figure 7 - Looking at vertical upstream face of north abutment.

September 7, 1979

Figure 8 - Downstream face of low-level outlet under north abutment.

September 7, 1979

Figure 9 - North abutment gate operating mechanism for low-level outlet.

September 7, 1979

Figure 10 - Looking along crest of south abutment to control tower, spillway and north abutment.

September 7, 1979

Figure 11 - View of 36-inch diameter steel low-level outlet pipe and south abutment control tower.

September 7, 1979

Figure 12 - Closeup view of 36" steel low-level outlet at south abutment.

September 7, 1979

Figure 13 - View of upstream face of south abutment and upstream face of control tower.

September 7, 1979

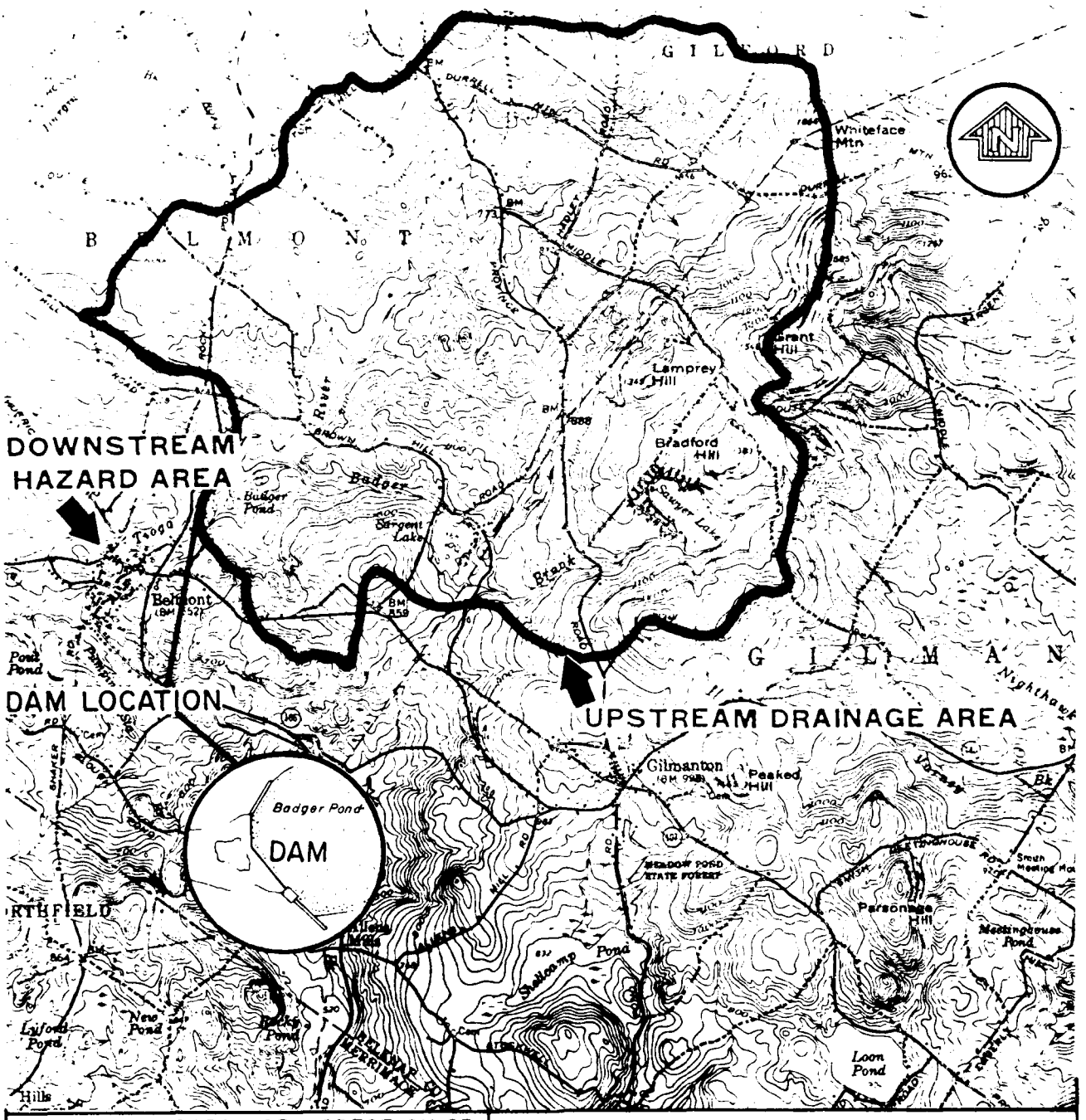
Figure 14 - Looking upstream at Badger Pond from crest of dam.

September 7, 1979

Figure 15 - Looking downstream at channel from crest of dam.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS



NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

BADGER POND DAM
BELMONT, NEW HAMPSHIRE

REGIONAL VICINITY MAP

NOVEMBER 1979

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

ANDERSON-NICHOLS & CO., INC. CONCORD, NH

MAP BASED ON U.S.G.S. 15 MINUTE QUADRANGLE SHEET. GILMANTON, NEW HAMPSHIRE, 1957

Anderson-Nichols & Company, Inc. Subject _____ Sheet No. 1 of _____

JOB NO. 3273-13 BADGER POND DAM Date _____ Computed KJS Checked LW

BREACH ANALYSIS (CONDITION #1)

DETERMINE DEGREE OF DOWNSTREAM HAZARD.

ASSUME WATER SURFACE AT TOP OF DAM = 583.0'

ASSUME MAXIMUM BREACH HEIGHT = 21.0'

$$Q_{P_1} = 8/27\ W_b \sqrt{g}\ y_c^{3/2}$$

WHERE W_b = BREACH WIDTH

g = 32.2 FT/SEC^2

y_0 = 21.0'

@ BADGER POND DAM W_b = 50' *

$$Q_{P_1} = 8/27\ (50)\ \sqrt{32.2}\ (21)^{3/2}$$

$$Q_{P_1} = 8090$$

* THE BREACH WIDTH WAS DETERMINED USING A FRACTION OF THE DAM WIDTH. THE STRUCTURAL ENGINEER FELT THAT A BREACH COULD OCCUR ALONG THE SOUTH PORTION OF THE SPILLWAY AND SOUTH ABUTMENT.

SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

BREACH ANALYSIS (CONT.)

TOTAL BREACH Q = Q_{P_1} + ADDITIONAL SPILLWAY DISCHARGE

ADDITIONAL SPILLWAY DISCHARGE = DISCHARGE OVER SPILLWAY OTHER THAN BREACHED AREA

$= Q = CLH^{3/2}$

$= Q = 2.7(80)(6)^{3/2}$

$= Q = 3174$ CFS

TOTAL BREACH Q = 8090 + 3174 = 11264 CFS

ANTECEDENT DISCHARGE = 4762 CFS△

△ FROM BADGER POND DAM RATING CURVE

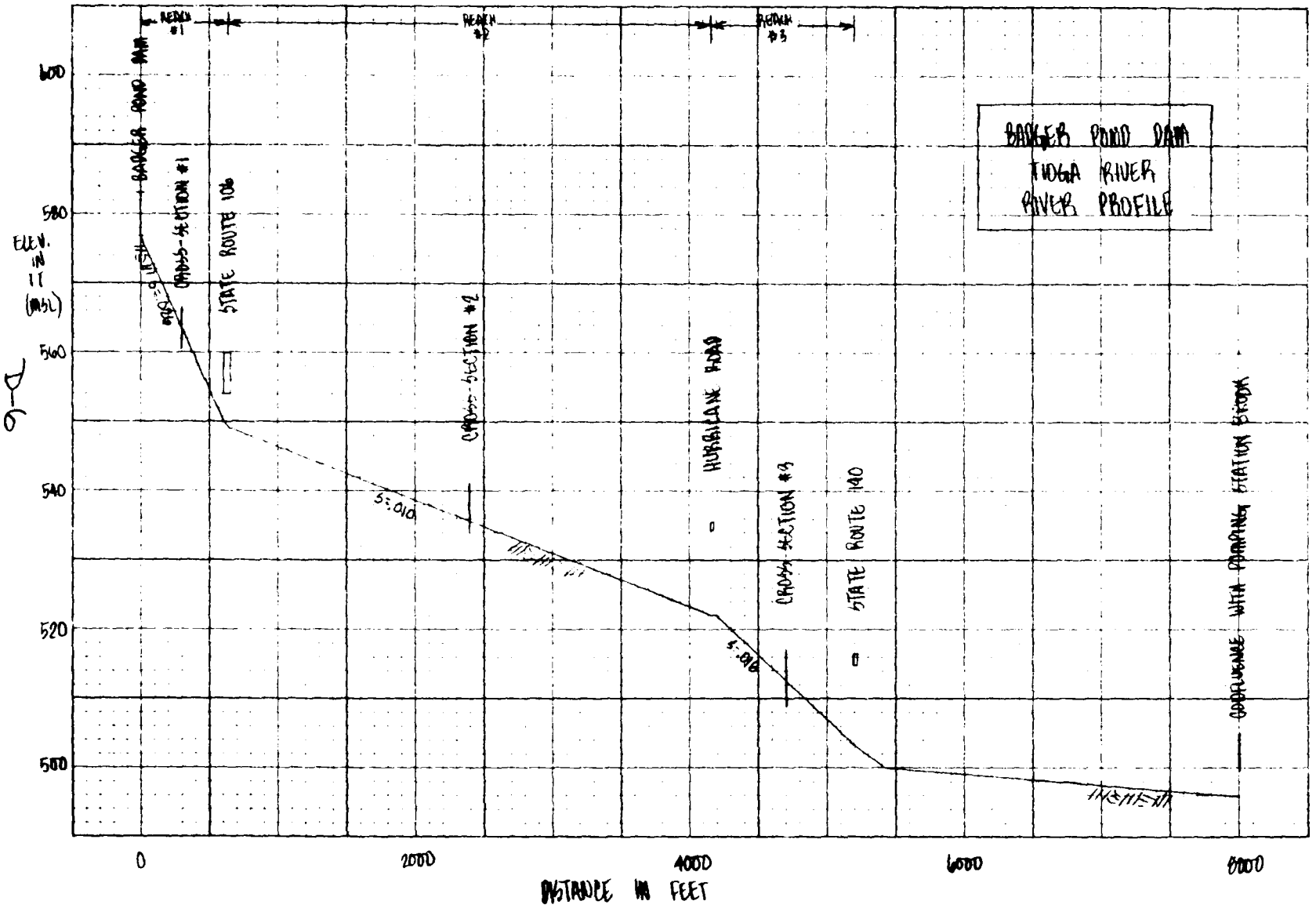
DOWNSTREAM HAZARD

APPROXIMATELY 5000 FEET DOWNSTREAM OF BADGER POND DAM IS THE TOWN OF BELMONT, N.H. THE OUTLET OF BADGER POND DAM IS THE TIOGA RIVER. THE TIOGA RIVER EXITS BADGER POND FLOWS OVER THE DAM AND APPROXIMATELY 600 FEET DOWNSTREAM FLOWS UNDER STATE ROUTE 106. APPROXIMATELY 3500 FEET DOWNSTREAM OF THIS CULVERT IS THE SECOND ROAD CROSSING NAMED HURRICANE ROAD IN BELMONT PROPER. APPROXIMATELY 1000 FEET DOWNSTREAM OF HURRICANE ROAD IS THE THIRD AND FINAL ROAD CROSSING NAMED STATE ROUTE 140. APPROXIMATELY 2500 FEET DOWNSTREAM OF THIS CROSSING THE TIOGA JOINS PUMPING STATION BROOK. A PROFILE OF THE TIOGA RIVER SHOWING THE LOCATION OF THE ABOVE CULVERTS AND THE LOCATION OF CROSS SECTIONS REPRESENTING THE REACHES IS SHOWN ON PAGE ___. WITHIN REACH #2 (FROM STATE ROUTE 106 TO HURRICANE

SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

DOWNSTREAM HAZARD (CONT.)

ROAD) THE TIOGA RIVER IS SPANNED BY A SMALL DAM. THIS STRUCTURE IS SO SMALL THAT ITS IMPOUNDMENT WILL HAVE A NEGLIGIBLE EFFECT ON RETARDING THE FLOOD WAVE FROM A BREACH OF BADGER POND DAM. THIS SMALL DAM IS LOCATED APPROXIMATELY 600' UPSTREAM OF THE HURRICANE ROAD CULVERT AND IS UNNAMED ON THE U.S.G.S. QUADRANGLE. THE HYDRAULIC CHARACTERISTICS WERE NOT ANALYZED IN COMPUTING THE DOWNSTREAM HAZARD OF BADGER POND DAM.


BARKER POND DAM
TIOGA RIVER
RIVER PROFILE
REACH #1
REACH #2
REACH #3
BARKER POND DAM
CROSS-SECTION #1
STATE ROUTE 106
CROSS-SECTION #2
HUBBARD LANE ROAD
CROSS-SECTION #3
STATE ROUTE 140
CONFLUENCE WITH PONDING STATION BRIDGE
S=.010
S=.010
S=.010
ELEV. IN FT (MSL)
600
580
560
540
520
500
0
2000
4000
6000
8000
DISTANCE IN FEET

SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

ANALYSES USING THE "PET" COMPUTER

ANDERSON-NICHOLS USES THE COMMODORE PET" COMPUTER FOR ANALYSES OF WEIR STRUCTURES AND REPRESENTATIVE CROSS-SECTIONS OF STREAM REACHES. THESE ANALYSES REQUIRE THE INPUT IN THE FORM OF A SERIES OF POINTS AND THE CORRESPONDING "N" VALUE OR "C" VALUE TO DETERMINE Q VS. STAGE. THE PROGRAM FOR DETERMINING Q VS. STAGE USES THE MANNINGS FORMULA:

$$Q = K(A)(R)^{2/3}$$

WHERE $K = \frac{1.49}{n}(S)^{1/2}$

n = FRICTION VALUE OF CROSS-SECTION

S = SLOPE OF REACH

A = AREA OF CROSS SECTION

R = HYDRAULIC RADIUS

QUARES /4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

ANALYSES USING THE "PET"

THE FIRST ANALYSIS WAS PERFORMED ON SECTION #1 (THE REPRESENTATIVE SECTION IN REACH #1 ON THE TIOGA RIVER. REACH #1 IS FROM BADGER POND DAM TO STATE RTE. 106)

STAGE	Q
3	438
6	1069
9	3806
12	9874
15	20305
18	36028
21	53392

THE SECOND ANALYSIS WAS PERFORMED ON SECTION #2 (THE REPRESENTATIVE SECTION IN REACH #2 ON THE TIOGA RIVER. REACH #2 IS FROM STATE RTE. 106 TO HURRICANE ROAD.)

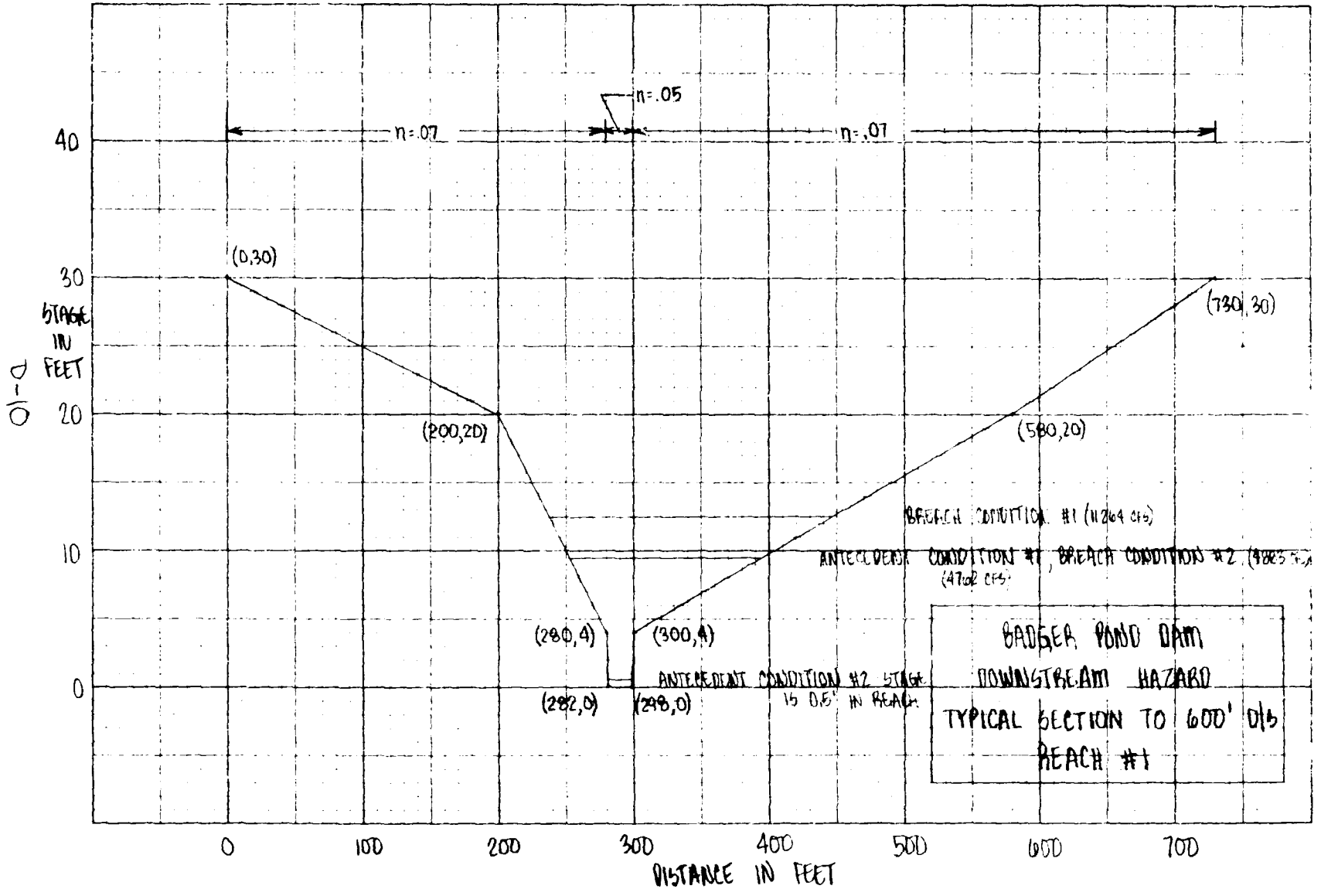
STAGE	Q
3	272
6	724
9	2382
12	5942
15	11994
18	21038
21	33557
24	41705

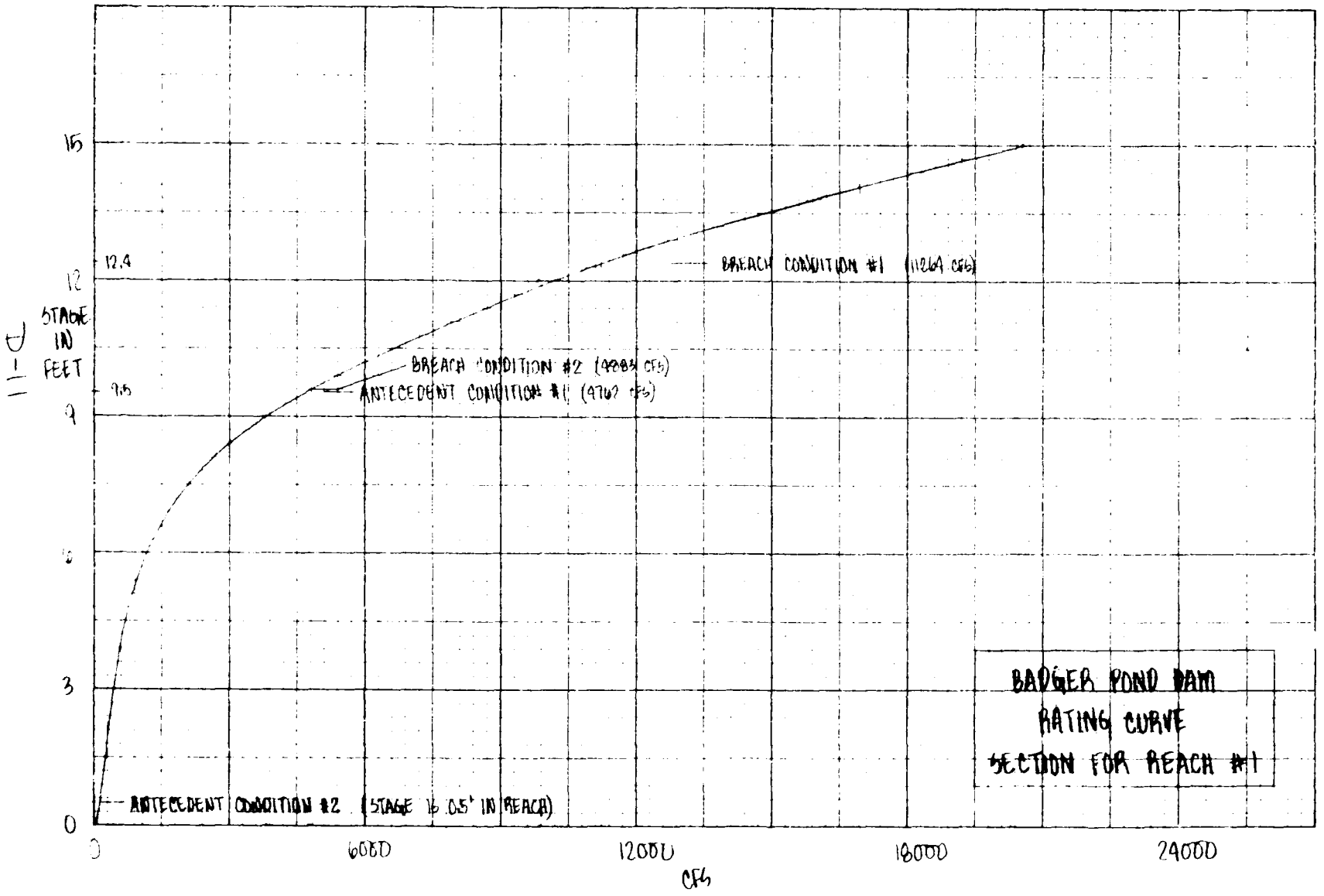
SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 3

ANALYSES USING THE "PET"

THE THIRD ANALYSIS WAS PERFORMED ON SECTION #3 (THE REPRESENTATIVE SECTION IN REACH #3 ON THE TIOGA RIVER. REACH #3 IS FROM HURRICANE ROAD TO STATE RTE. 140)

STAGE	Q
1.9	169
3.8	526
5.7	875
7.6	2972
9.5	6295
11.4	12364
13.3	20930
15.2	32295
17.1	46749
19.0	64626


n=.07
n=.05
n=.07
(0,30)
(200,20)
(280,4)
(282,0)
(298,0)
(300,4)
(580,20)
(730,30)
ANTECEDENT CONDITION #2 STAGE IS 0.5' IN REACH
BREACH CONDITION #1 (1264 cfs)
ANTECEDENT CONDITION #1, BREACH CONDITION #2 (4782 cfs)
BADGER POND DAM
DOWNSTREAM HAZARD
TYPICAL SECTION TO 600' D/S
REACH #1
STAGE IN FEET
DISTANCE IN FEET
0
10
20
30
40
0
100
200
300
400
500
600
700


15
12
9
6
3
0
12.4
9.5
STAGE IN FEET
BREACH CONDITION #1 (11264 CFS)
BREACH CONDITION #2 (4284 CFS)
ANTECEDENT CONDITION #1 (9762 CFS)
ANTECEDENT CONDITION #2 (STAGE IS .05' IN REACH)
0
6000
12000
18000
24000
CFS
BADGER POND DAM
RATING CURVE
SECTION FOR REACH #1

Anderson-Nichols & Company, Inc. Subject _____ Sheet No. 11 of _____

JOB NO. Date _____ Computed _____ Checked _____

STATE ROUTE 106 CONCRETE BOX CULVERT

DETERMINE CULVERT CAPACITY AT VARIOUS STAGES. CULVERT FLOW UNTIL STAGE 6.0' (USE MANNINGS EQUATION $Q = K(A)(R)^{2/3}$ WHERE $K = \frac{1.49}{n}(S)^{1/2}$, "n" VALUE OF CULVERT = 0.025, S SLOPE THROUGH CULVERT = .017, A = AREA, R = HYDRAULIC RADIUS) PRESSURE FLOW THROUGH CULVERT FROM STAGE 6.0' UNTIL 9.5' (USE ORIFICE EQUATION $Q = Ca\sqrt{2gH}$, WHERE C = COEFFICIENT OF DISCHARGE, g = 32.2 FT/SEC^2, H = HEAD MEASURED FROM CENTROID) PRESSURE FLOW AND WEIR FLOW FROM STAGE 9.5' AND UP (USE ORIFICE EQUATION ABOVE AND WEIR EQUATION $Q = CLH^{3/2}$ WHERE C = WEIR COEFFICIENT OVER ROAD, L = LENGTH OF WEIR, H HEAD MEASURED FROM TOP OF WEIR).

CULVERT SIZE 6' (H) X 30' (W)

STAGE VS. Q CHART FOLLOWS.

Anderson-Nichols & Company, Inc.

Subject

Sheet No. 12 of

Date

Computed

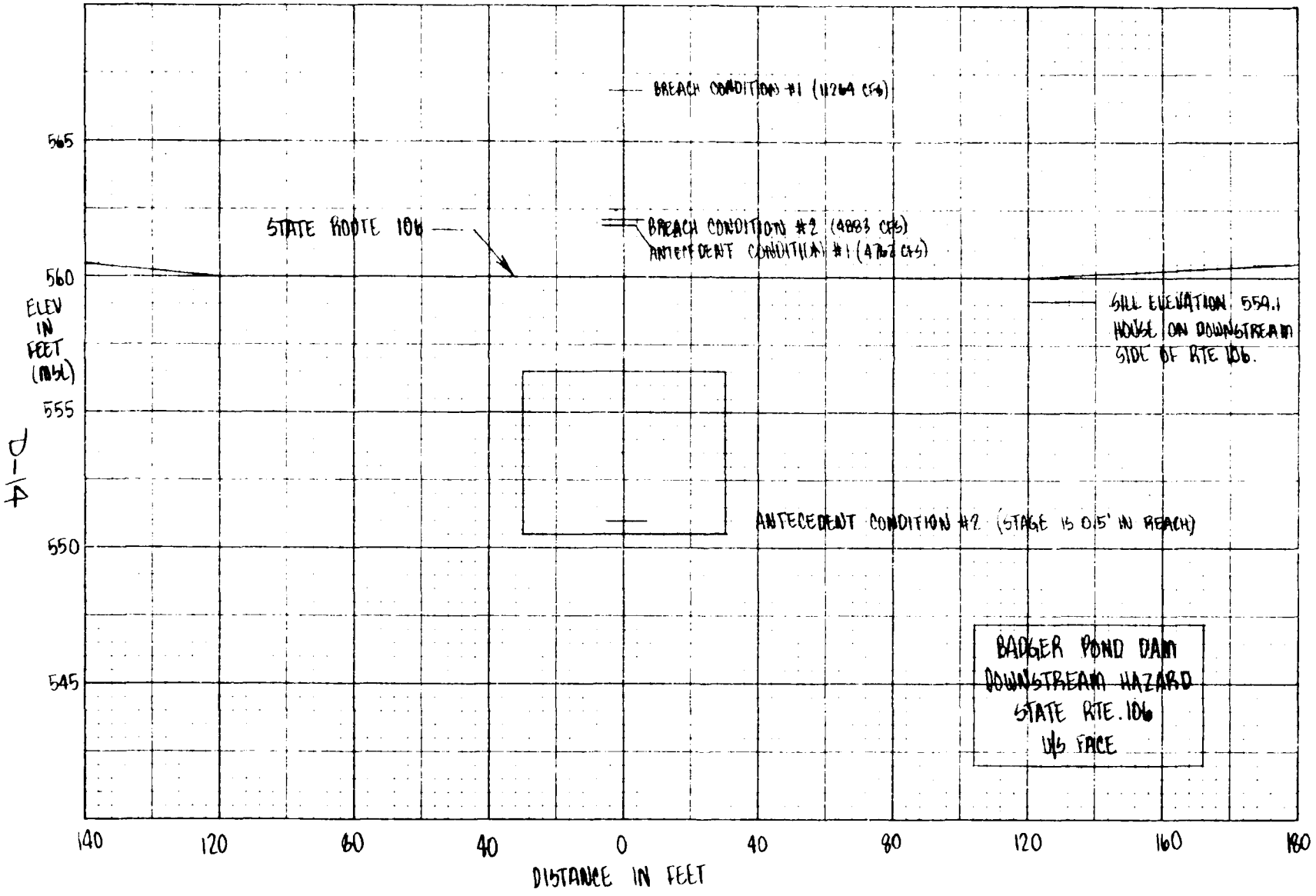
Checked

JOB NO.

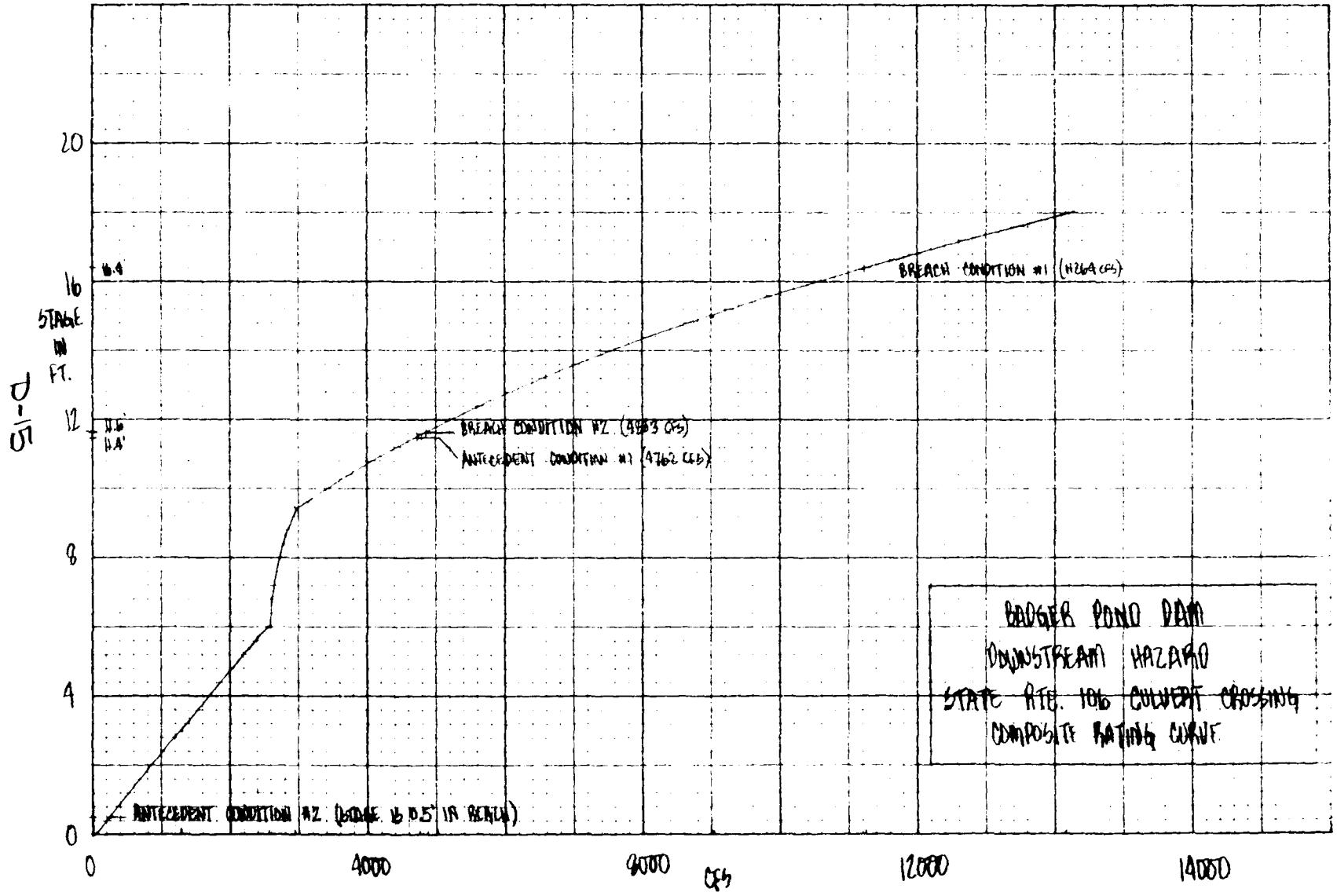
SQUARES 1/4 IN. SCALE

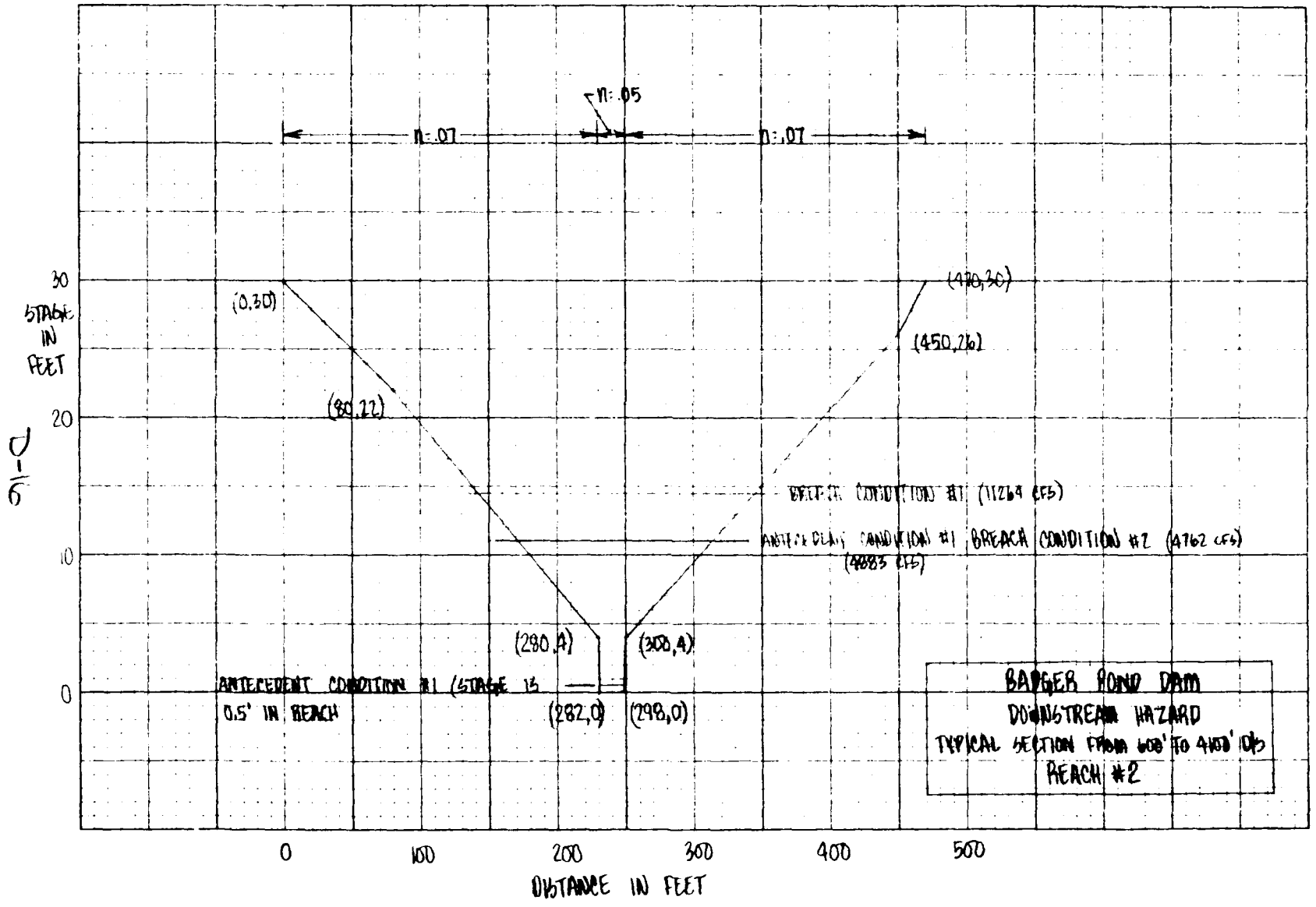
STATE ROUTE 106 CONCRETE BOX CULVERT (CONT.)

STAGE	$Q_{ORIFICE}$	Q_{WEIR}	Q_{TOTAL}	COMMENTS
3	1288		1288	
6	2576		2576	
9.5	2946		2946	
12	3467	1542	5009	L=150
15	4003	5031	9034	L=150
18	4776	9665	14141	L=150

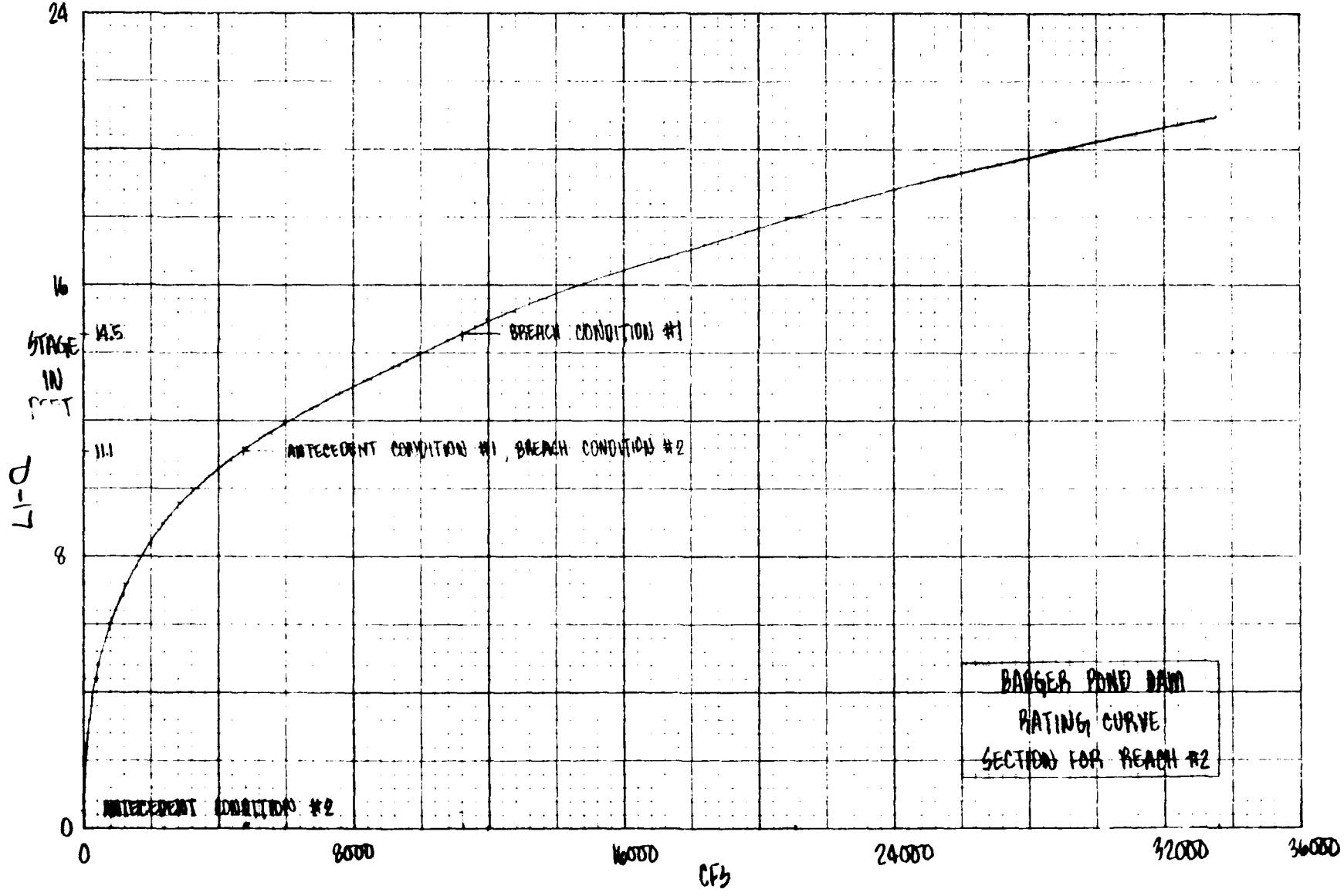

BREACH CONDITIONS #1 (11264 CFS)
STATE ROUTE 106
BREACH CONDITION #2 (4883 CFS)
ANTECEDENT CONDITION #1 (4767 CFS)
SILL ELEVATION 559.1
HOUSE ON DOWNSTREAM
SIDE OF RTE 106.
ANTECEDENT CONDITION #2 (STAGE IS 0.5' IN REACH)
BADGER POND DAM
DOWNSTREAM HAZARD
STATE RTE. 106
U/S FACE
565
560
555
550
545
ELEV
IN
FEET
(MSL)
140
120
80
40
0
40
80
120
160
180
DISTANCE IN FEET

D-4


20
16
12
8
4
0
STAGE IN FT.
0
4000
8000
12000
14000
CFS
BREACH CONDITION #1 (11264 CFS)
BREACH CONDITION #2 (9883 CFS)
ANTECEDENT CONDITION #1 (4762 CFS)
ANTECEDENT CONDITION #2 (STAGE IS 0.5' IN POND)
BROWER POND DAM
DOWNSTREAM HAZARD
STATE RTE. 104 CULVERT CROSSING
COMPOSITE RATING CURVE


n=.07
n=.05
n=.07
30
20
10
0
STAGE IN FEET
(0,30)
(80,22)
(280,4)
(300,4)
(450,26)
(470,30)
ANTECEDENT CONDITION #1 (STAGE IS 0.5' IN REACH
(282,0)
(298,0)
BREACH CONDITION #1 (11269 CFS)
ANTECEDENT CONDITION #1 (4883 CFS)
BREACH CONDITION #2 (4762 CFS)
BADGER POND DAM
DOWNSTREAM HAZARD
TYPICAL SECTION FROM 600' TO 4100' DS
REACH #2
0
100
200
300
400
500
DISTANCE IN FEET

C-6



P-17

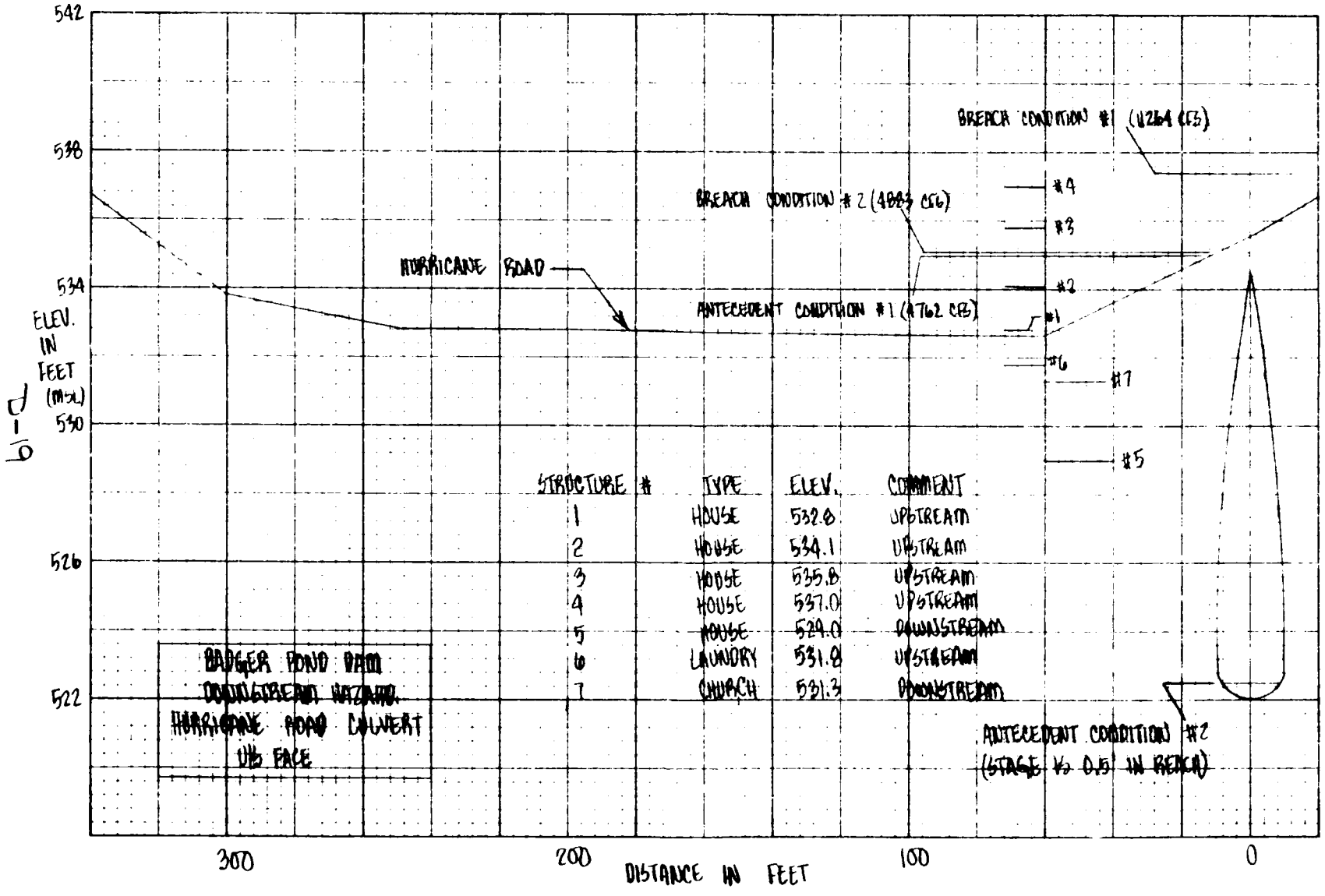
SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

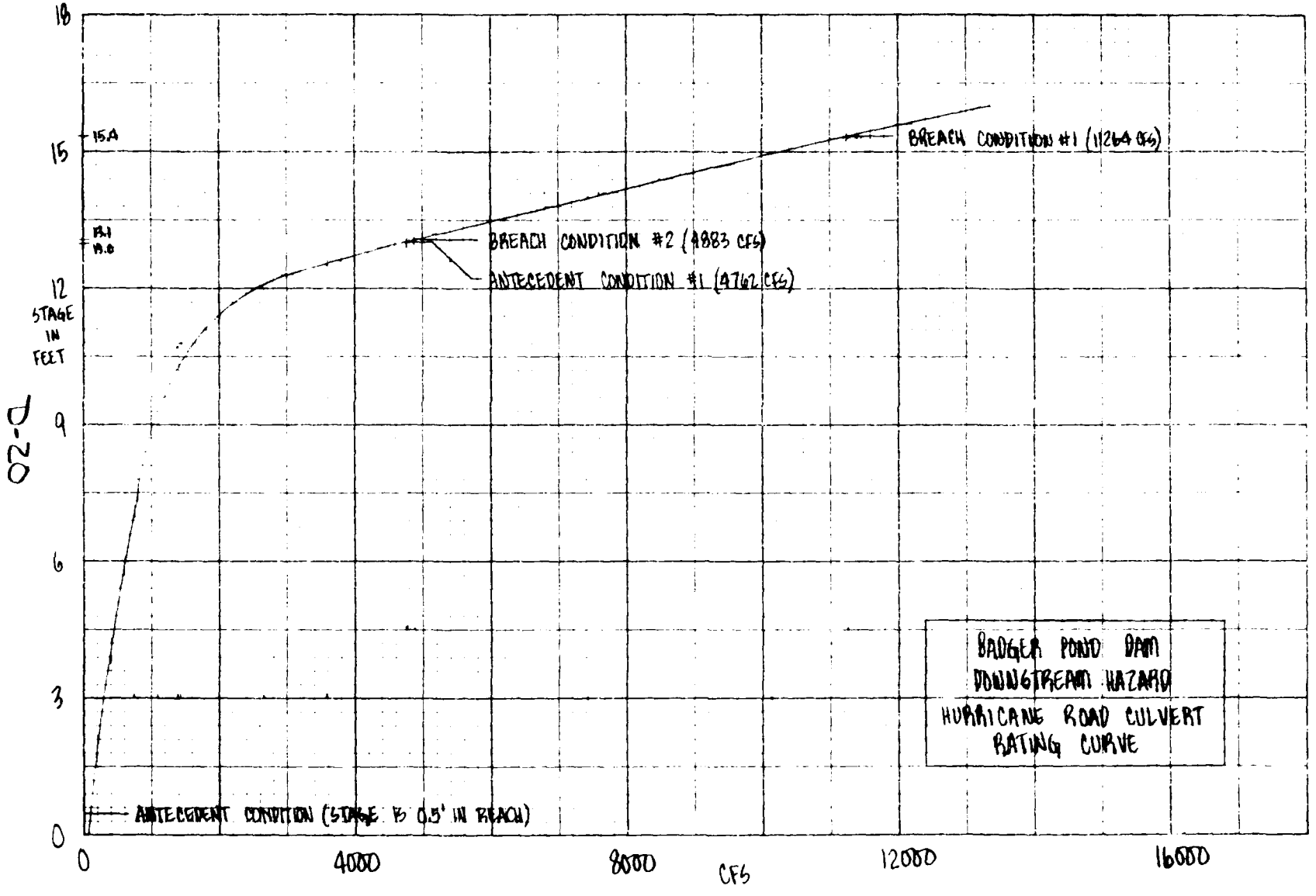
HURRICANE ROAD PIPE ARCH

DETERMINE CULVERT CAPACITY AT VARIOUS STAGES. PIPE FLOW UNTIL STAGE 10.7. AT 10.8 - 12.4, LOW FLOW THROUGH THE CULVERT AND WEIR FLOW OVER HURRICANE ROAD. AT 12.5 - 16.0 PRESSURE FLOW THROUGH THE CULVERT AND WEIR FLOW OVER HURRICANE ROAD.

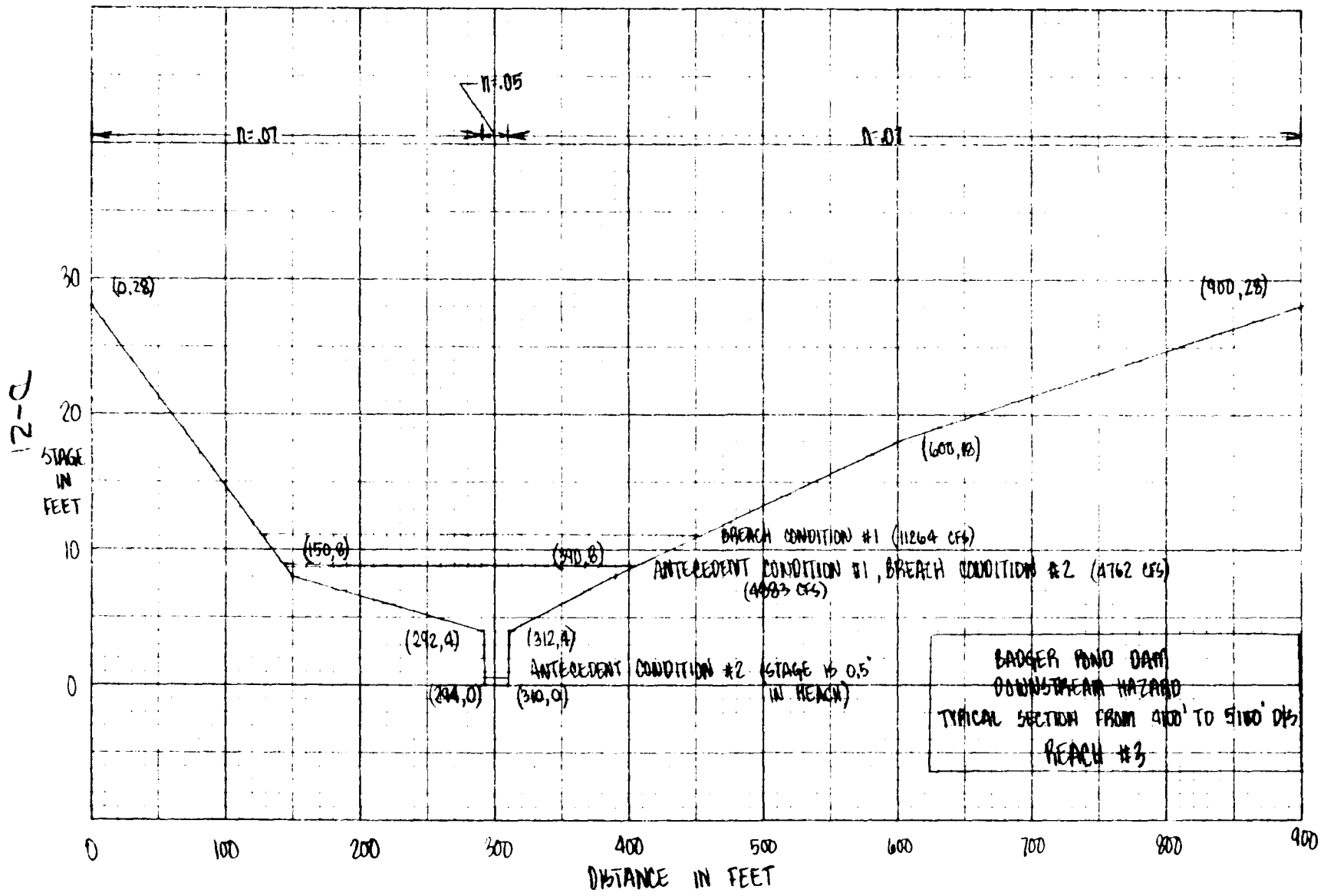
STAGE (HW)	HW/D	$Q_{ORIFICE}$	Q_{WEIR}	Q_{TOTAL}	COMMENTS
7	0.56	755		755	
9	0.71	1100		1100	
10.7	0.86	1400		1400	
10.8	0.86	1410	9	1419	L = 110'
12	0.96	1600	1081	2681	L = 270'
12.5	1.00	1740	1858	3598	L = 285'
14	1.12	2000	5422	1422	L = 335'
15	1.20	2080	8065	10145	L = 335'
16	1.28	2300	11036	13336	L = 335'

CULVERT 12.5'D X 18.5'B, ROAD ELEV. = 532.7 C 2.7 (WEIR)
CULVERT CAPACITY FROM "HANDBOOK OF STEEL DRAINAGE & HIGHWAY CONSTRUCTION PRODUCTS" NOMOGRAPH P. 165


542
538
534
530
526
522
ELEV. IN FEET (MSL)
BREACH CONDITION #1 (4264 CFS)
BREACH CONDITION #2 (4883 CFS)
#4
#3
#2
#1
#6
#7
#5
HURRICANE ROAD
ANTECEDENT CONDITION #1 (1762 CFS)
STRUCTURE # TYPE ELEV. COMMENT
1 HOUSE 532.0 UPSTREAM
2 HOUSE 534.1 UPSTREAM
3 HOUSE 535.8 UPSTREAM
4 HOUSE 537.0 UPSTREAM
5 HOUSE 529.0 DOWNSTREAM
6 LAUNDRY 531.8 UPSTREAM
7 CHURCH 531.3 DOWNSTREAM
BADGER POND DAM
DOWNSTREAM HAZARD
HURRICANE ROAD CULVERT
U/S FACE
ANTECEDENT CONDITION #2
(STAGE V2 0.5' IN REACH)
300
200
100
0
DISTANCE IN FEET

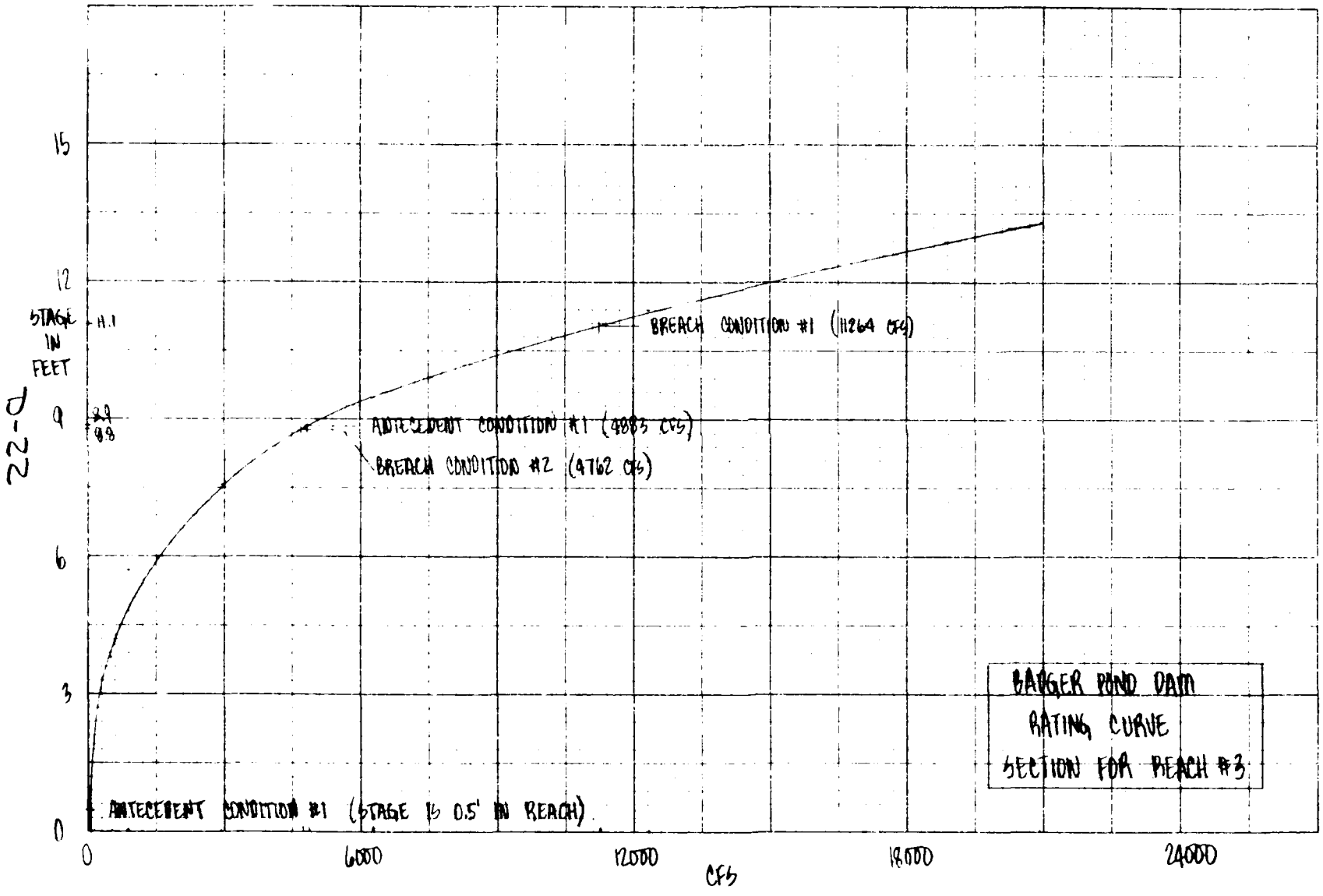

18
15
12
9
6
3
0
15.4
13.1
11.8
STAGE IN FEET
BREACH CONDITION #1 (11264 CFS)
BREACH CONDITION #2 (8883 CFS)
ANTECEDENT CONDITION #1 (4762 CFS)
ANTECEDENT CONDITION (STAGE IS 0.5' IN REACH)
0
4000
8000
12000
16000
CFS
BADGER POND DAM
DOWNSTREAM HAZARD
HURRICANE ROAD CULVERT
RATING CURVE

P-20


n=.07
n=.05
n=.07
(0,28)
(900,28)
(600,18)
(150,8)
(310,8)
BREACH CONDITION #1 (11264 CFS)
ANTECEDENT CONDITION #1, BREACH CONDITION #2 (4762 CFS)
(4983 CFS)
(292,4)
(312,4)
ANTECEDENT CONDITION #2 (STAGE = 0.5' IN REACH)
(294,0)
(310,0)
BADGER POND DAM
DOWNSTREAM HAZARD
TYPICAL SECTION FROM 4100' TO 5100' D/S
REACH #3
30
20
10
0
STAGE IN FEET
0
100
200
300
400
500
600
700
800
900
DISTANCE IN FEET

J-12

22-D


15
12
9
6
3
0
STAGE IN FEET
H.1
BREACH CONDITION #1 (11264 CFS)
ANTECEDENT CONDITION #1 (4883 CFS)
BREACH CONDITION #2 (4762 CFS)
ANTECEDENT CONDITION #1 (STAGE IS 0.5' IN REACH)
0
6000
12000
18000
24000
CFS
BADGER POND DAM
RATING CURVE
SECTION FOR REACH #3

Anderson-Nichols & Company, Inc. Subject _____ Sheet No. 22 of _____

JOB NO. Date _____

Computed KSS

Checked [illegible]

SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

STATE ROUTE 140 CONCRETE BOX CULVERT

DETERMINE CULVERT CAPACITY AT VARIOUS STAGES CULVERT FLOW UNTIL STAGE 12.0' (USE MANNINGS EQUATION $Q = K(A)(R)^{2/3}$ WHERE $K = \frac{1.49}{n}(S)^{1/2}$, $n = .025$, S SLOPE THROUGH CULVERT, A AREA, R HYDRAULIC RADIUS). PRESSURE FLOW THROUGH CULVERT FROM STAGE 12.0' UNTIL 13.4' (USE ORIFICE EQUATION $Q = CA\sqrt{2gH}$, WHERE C COEFFICIENT OF DISCHARGE, g 32.2 ft/sec^2, H HEAD MEASURED FROM CENTROID) FREE FLOW AND WEIR FLOW FROM STAGE 13.4' AND UP (USE ORIFICE EQUATION, IF AT WEIR ELEVATION $Q = CLH^{3/2}$ WHERE C WEIR COEFFICIENT, L LENGTH OF WEIR, H HEAD MEASURED FROM TOP OF WEIR)

CULVERT SIZE = 12' (W) x 3' (H)

STAGE VS Q MANNING EQUATION

Anderson-Nichols & Company, Inc.

Subject _____

Sheet No. 23 of _____

Date _____

Computed [illegible]

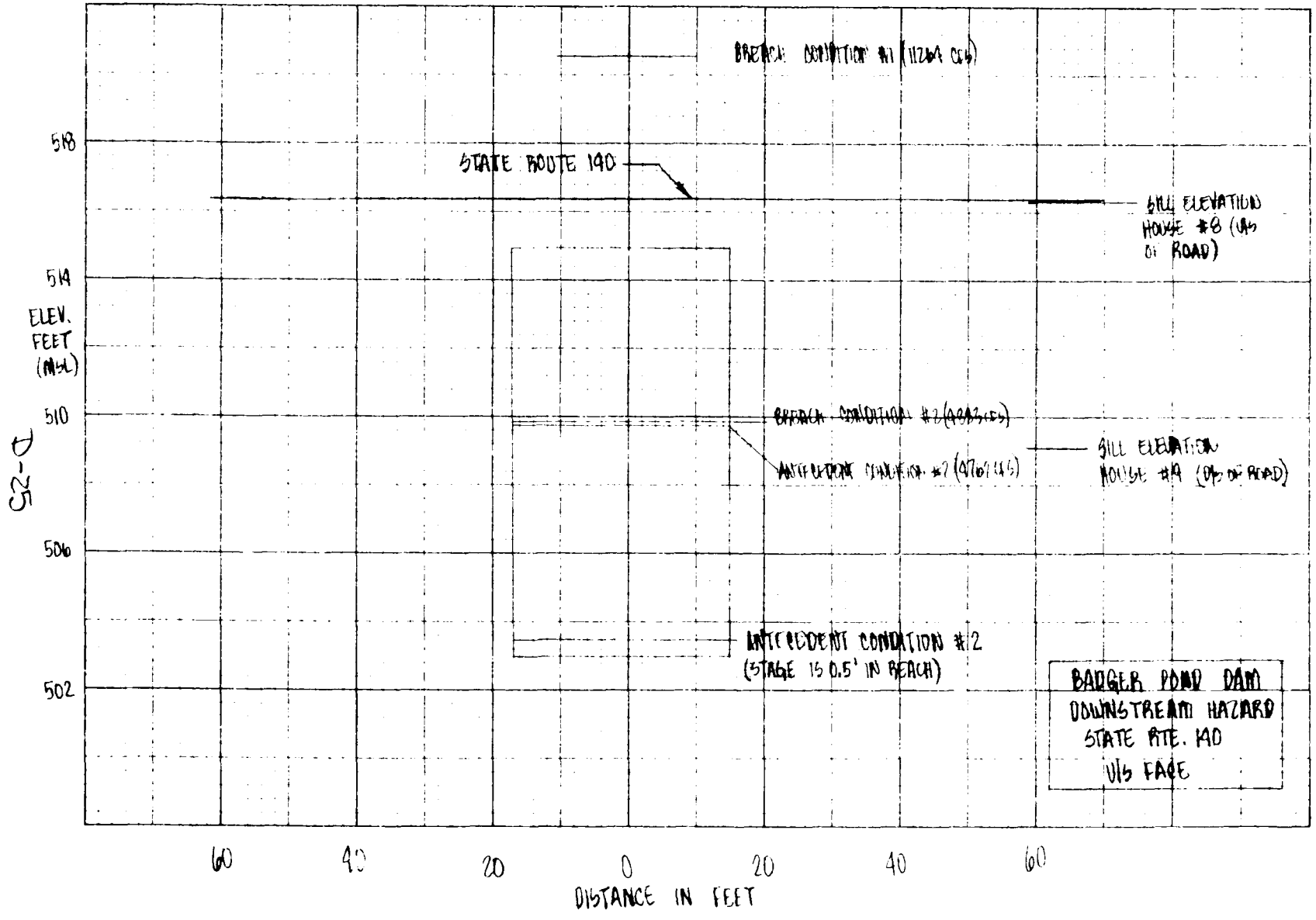
Checked [illegible]

JOB NO.

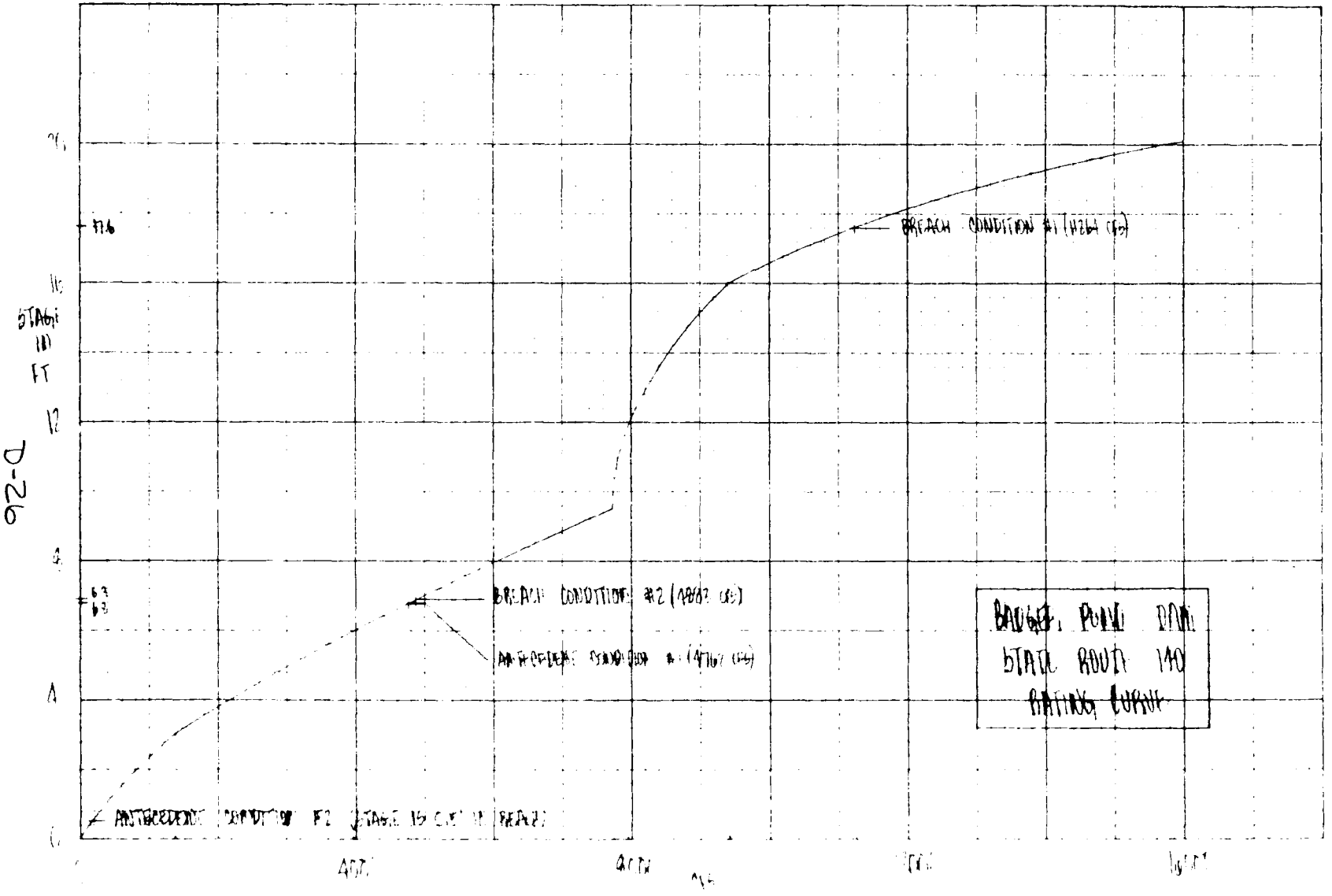
SQUARES 4 IN. SCALE

STATE ROUTE 140 CONCRETE BOX CULVERT (CONT)

STAGE	$Q_{ORIFICE}$	Q_{WEIR}	Q_{TOTAL}	COMMENTS
3	1384		1384	
6	3984		3984	
9.5	7765		7765	
12	7967		7967	
16	7796	1635	9431	L=150
20	9224	6613	15837	L=150


BREACH CONDITION #1 (1126' CFS)
STATE ROUTE 140
SILL ELEVATION HOUSE #8 (U/S OF ROAD)
518
514
510
506
502
ELEV. FEET (MSL)
BREACH CONDITION #2 (4883 CFS)
ANTECEDENT CONDITION #2 (976' CFS)
SILL ELEVATION HOUSE #9 (D/S OF ROAD)
ANTECEDENT CONDITION #2
(STAGE IS 0.5' IN BEACH)
BADGER POND DAM
DOWNSTREAM HAZARD
STATE RTE. 140
U/S FACE
60
40
20
0
20
40
60
DISTANCE IN FEET

C2-4


BREACH CONDITION #1
BREACH CONDITION #2
BAUER POND DAM
STATE ROUTE 140
RATING CURVE

SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

BREACH ANALYSIS (CONDITION #2)

UNDER BREACH ANALYSIS CONDITION #1 IT HAS BEEN DETERMINED THAT THE INCREASE IN FLOOD STAGE FROM ANTECEDENT CONDITIONS TO BREACH CONDITIONS DOES NOT INCREASE THE DEGREE OF HAZARD DOWNSTREAM. UNDER CONDITION #1, THE ANTECEDENT CONDITIONS ALONE ENDANGER SEVEN HOMES IN THE TOWN OF BELMONT, NH.

UNDER BREACH ANALYSIS CONDITION #2, A DIFFERENT SET OF FLOOD CONDITIONS WILL EXIST. WITH THIS ANALYSIS IT IS ASSUMED THAT THE ANTECEDENT CONDITIONS WILL ALLOW FLOW OVER THE DAM APPROXIMATELY EQUAL TO THAT ON THE INSPECTION DATE. THE ANTECEDENT STAGE AT THE DOWNSTREAM CULVERTS AND REACHES SHALL BE 0.5 FOOT. THE PEAK FAILURE OUTFLOW (Q_p) FOR CONDITION #2 FOLLOWS.

BREACH ANALYSIS (CONDITION #2) CONT.

ASSUME WATER SURFACE AT TOP OF SPILLWAY = 577.0'

ASSUME MAXIMUM BREACH HEIGHT = 15.0'

$$Q_{P_1} = 8/27\ W_b \sqrt{g}\ y_0^{3/2}$$

WHERE W_b = BREACH WIDTH

$g = 32.2$ FT/SEC^2

$y_0 = 15.0'$

@ BADGER POND DAM $W_b = 50'$

$$Q_{P_1} = 8/27\ (50)\ \sqrt{32.2}\ (15)^{3/2}$$

$Q_{P_1} = 4883$ CFS

TOTAL BREACH Q = 4883 CFS

ANTECEDENT Q @ DAM = 0 CFS

SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

BREACH ANALYSIS SUMMARY

WITH AN INCREASED STAGE AS THE RESULT OF A DAM BREACH AT BADGER POND DAM, THE FOLLOWING STRUCTURES ARE AFFECTED.

CONDITION #1

ON STATE ROUTE 106 1 RESIDENCE ON DOWNSTREAM SIDE OF ROAD ADJACENT TO HURRICANE ROAD CULVERT 4 RESIDENCES, 1 LAUNDRY ON UPSTREAM SIDE OF CULVERT AND 1 RESIDENCE, 1 CHURCH ON DOWNSTREAM OF CULVERT

ADJACENT TO STATE ROUTE 140 2 RESIDENCES

CONDITION #2

ON STATE ROUTE 106 1 RESIDENCE ON DOWNSTREAM SIDE OF ROAD ADJACENT TO HURRICANE ROAD CULVERT 2 RESIDENCES, 1 LAUNDRY ON UPSTREAM SIDE OF CULVERT AND 1 RESIDENCE, 1 CHURCH ON DOWNSTREAM OF CULVERT.

ADJACENT TO STATE ROUTE 140 1 RESIDENCE

SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

TEST FLOOD ANALYSIS

DRAINAGE AREA 16 SQUARE MILES

HAZARD CLASSIFICATION HIGH

TEST FLOOD RANGE ½PMF ⇒ PMF

CHOSEN TEST FLOOD PMF

STEP 1. DETERMINE PEAK INFLOW Q_P, USING "PRELIMINARY GUIDANCE FOR ESTIMATING MAXIMUM PROBABLE DISCHARGES IN PHASE I DAM SAFETY INVESTIGATIONS, MARCH, 1978". THE PMF WILL BE CALCULATED USING A COMBINED VALUE. THE PMF COMBINES THE OUTFLOW FROM SARGENT LAKE DAM PLUS THE ADDITIONAL DISCHARGE FROM THE BADGER POND DAM SUB DRAINAGE AREA. THE SLOPE FOR THE SUB-DRAINAGE AREA IS 175 FT/MI; THE "MOUNTAINOUS CURVE" WILL BE USED. THE DRAINAGE AREA OF THE SUB AREA IS

SQUARES 1/4 IN. SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

TEST FLOOD ANALYSIS (CONT.)

13.2 SQUARE MILES. USING THESE VALUES A 1900 CSM RATE IS DETERMINED FOR THE SUB AREA. THE PMF FOR THE SUB-AREA = 13.2 (1900) = 25080 CFS. OUTFLOW FROM SARGENT LAKE = 5850 CFS

PEAK INFLOW (Q_{P_1}) = 30930, STAGE = 590.6$^{\Delta}$

NORMAL STORAGE = 180 ACRE-FT, STAGE = 577.0, SURFACE AREA = 20 ACRES

STAGE 580.0 = SURFACE AREA = 45 ACRES

STAGE 600.0 = SURFACE AREA = 95 ACRES

USING THE "FRUSTRUM OF THE PYRAMID" TO FIND STORAGE ESTIMATES FOR THESE ADDITIONAL POINTS

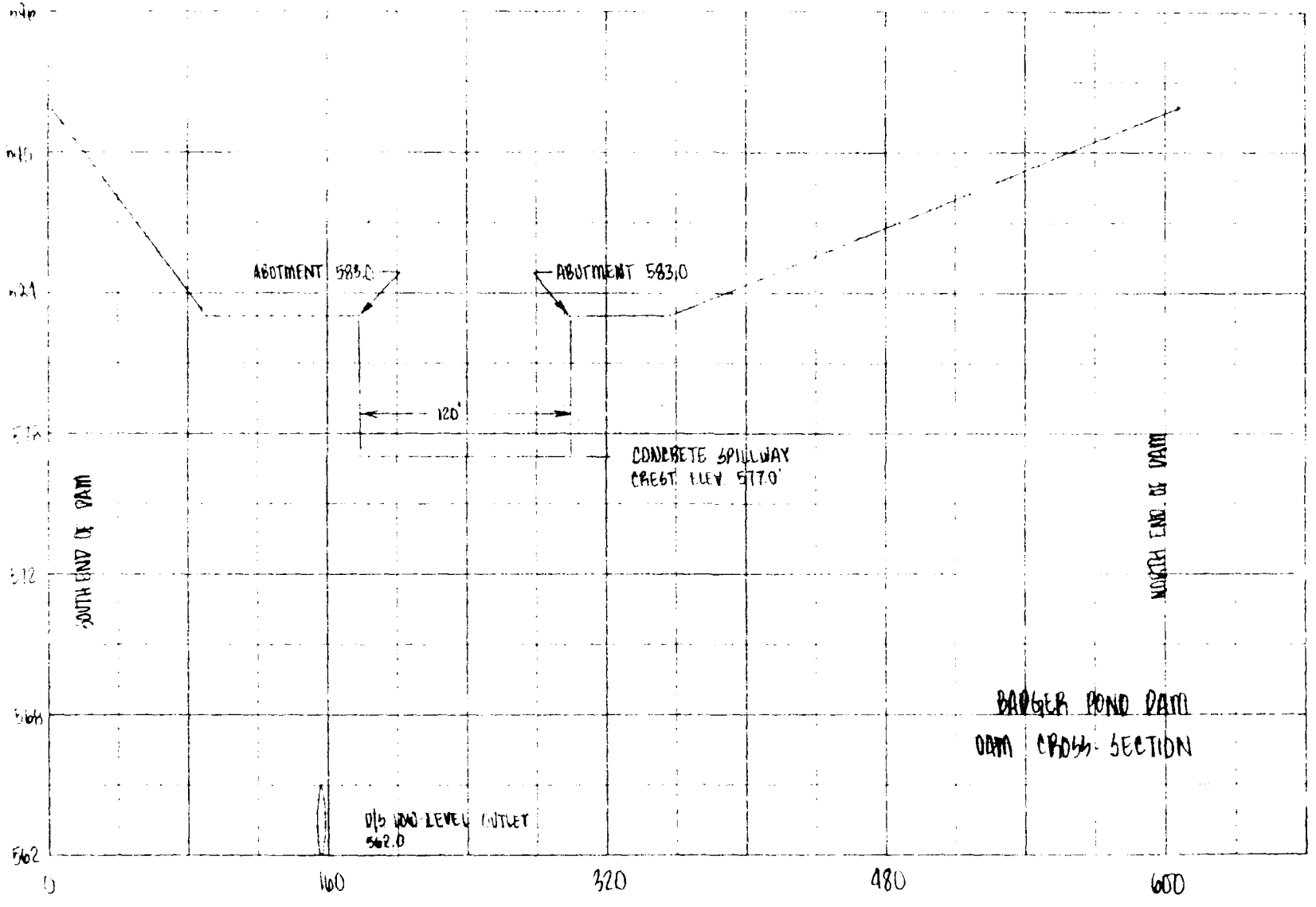
$$V = \frac{1}{3} H \left(b_1 + b_2 + \sqrt{b_1 b_2} \right)$$

$$V = \frac{1}{3} 3 \left(20 + 45 + \sqrt{25 \cdot 45} \right)$$

$$V = 98.5 \text{ ACRE-FT}$$

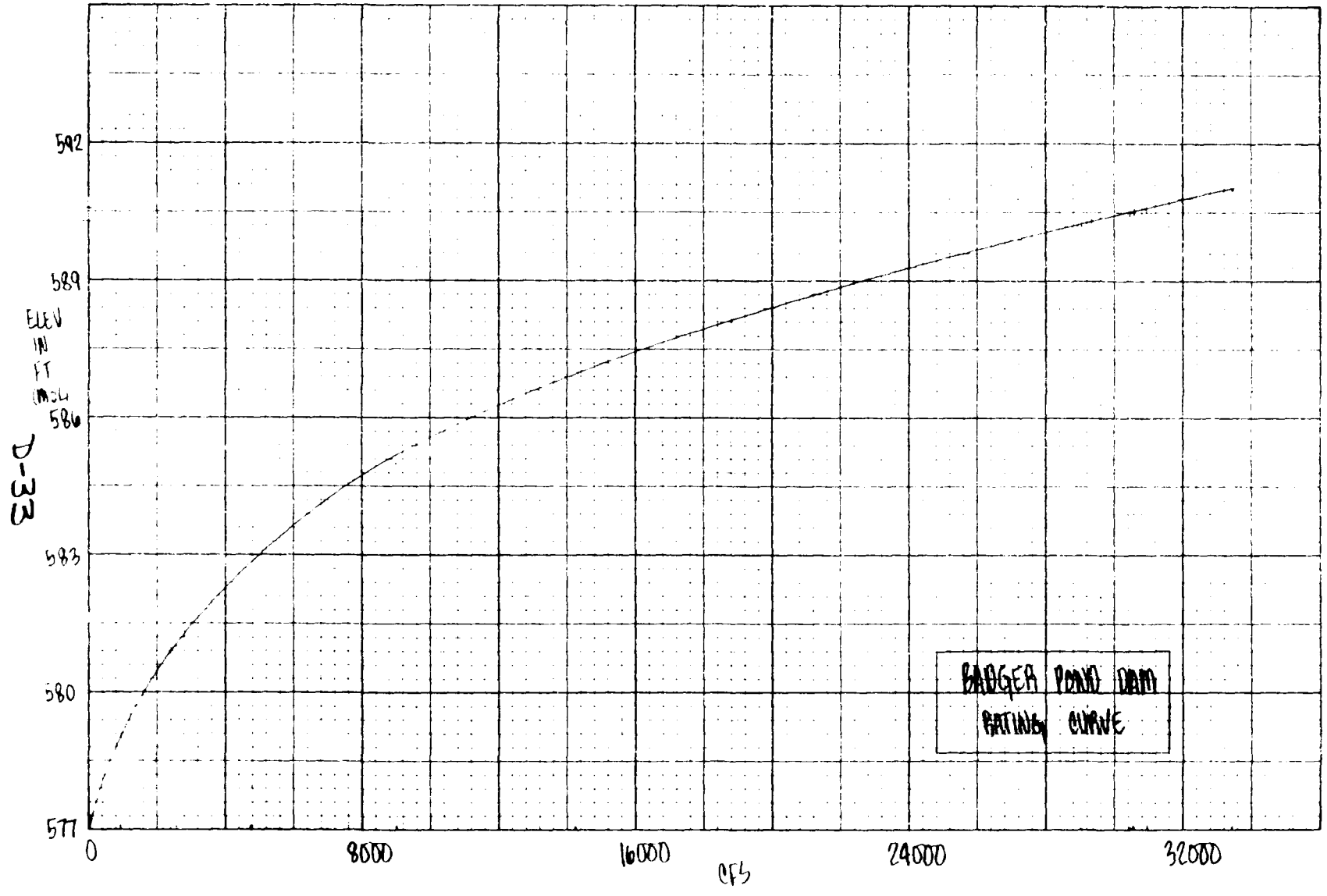
@ STAGE 580.0 STORAGE = 98.5 + 180 = 278.5 ≈ 280 ACRE-FT

$^{\Delta}$ FROM BADGER POND DAM RATING CURVE



BARGER POND DAM

DAM CROSS-SECTION


592
589
586
583
580
577
ELEV IN FT
0
8000
16000
24000
32000
CFS
BADGER POND DAM
RATING CURVE

D-33

TEST FLOOD ANALYSIS (CONT.)

$V = 1/3\ H(b_1 + b_2 + \sqrt{b_1 b_2})$

$V = 1/3(20)(45 + 85 + \sqrt{45 \cdot 85})$

$V = 1279.0$ SAY 1280 ACRE FEET

@ STAGE 600.0 STORAGE = 1280 + 280 = 1560 ACRE-FT.

1010 - 180 = 830 ACRE-FT.

$830\ \text{AC-FT} \cdot \frac{1}{16\ \text{mi}^2} \cdot \frac{1\ \text{mi}^2}{640\ \text{AC-FT}} \cdot \frac{12\ \text{IN}}{\text{FT}} = 0.97$ INCH RUNOFF = STOR 1

$Q_{P_2} = Q_{P_1}\left(1 - \frac{\text{STOR1}}{19}\right) = 30930\left(1 - \frac{0.97}{19}\right)$

$Q_{P_2} = 29350$ CFS

DETERMINE SURCHARGE HEIGHT TO PASS Q_{P_2} OF 29350

Q_{P_2} DISCHARGE DETERMINES ELEVATION 590.3

@ 590.3 STORAGE = 980 ACRE FEET

980 - 180 = 800 ACRE-FT.

$800\ \text{AC-FT} \cdot \frac{1}{16\ \text{mi}^2} \cdot \frac{1\ \text{mi}^2}{640\ \text{AC-FT}} \cdot \frac{12\ \text{IN}}{\text{FT}} = 0.94$ INCH RUNOFF STOR 2

SQUARES 1/4 IN. SCALE

TEST FLOOD ANALYSIS (CONT.)

AVERAGE STOR 1 & STOR 2

STOR 1 : 0.97
STOR 2 : 0.94
AVERAGE : 0.955" OR 0.08 FT. RUNOFF

$0.08\,FT \cdot \frac{16\,MI^2}{1} \cdot \frac{640\,AC}{MI^2} = 819$ ACRE-FEET

819 AC-FT + 180 AC FT = 999 AC-FT

999 AC-FT OF STORAGE ⇒ 590.5

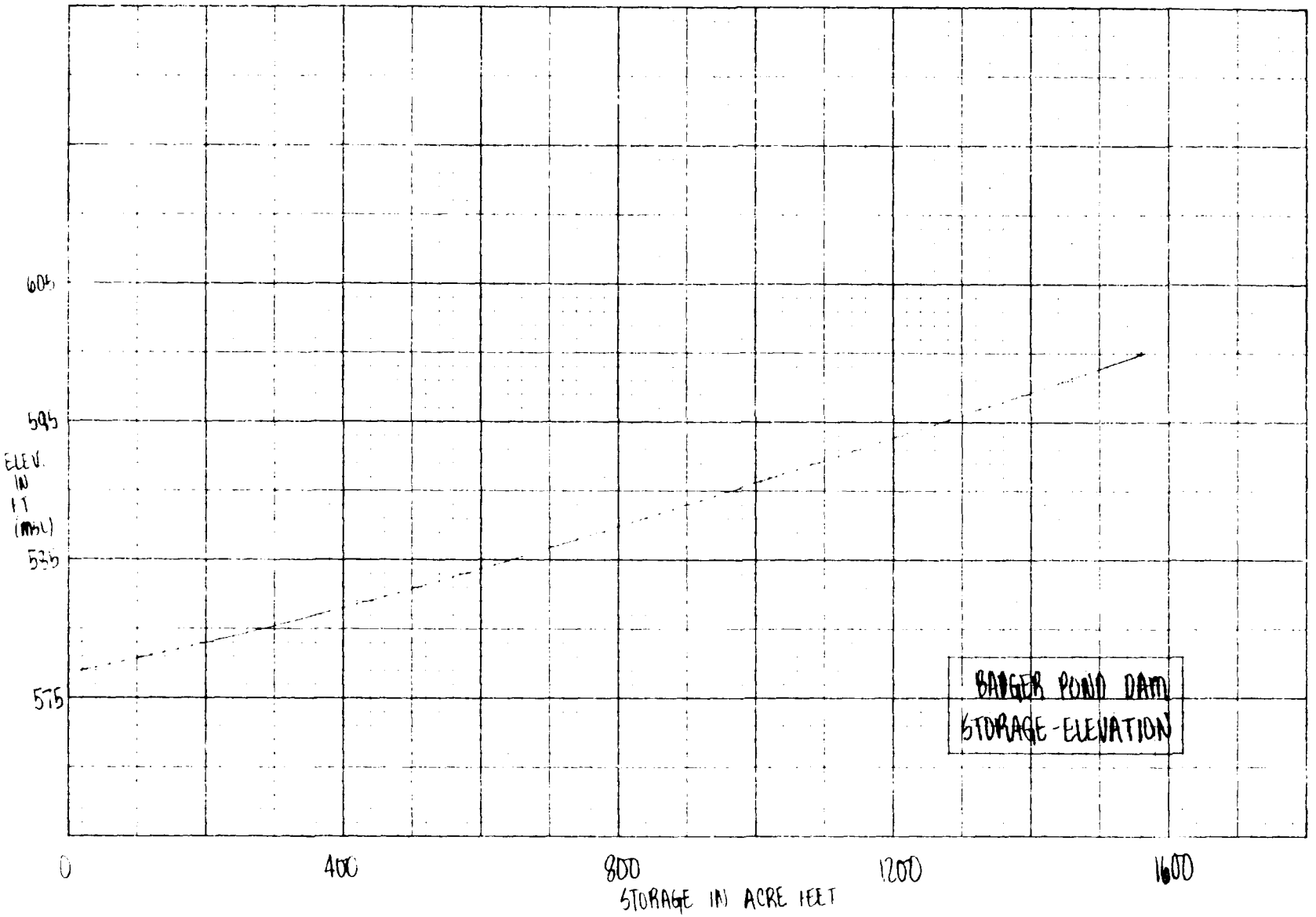
TEST FLOOD = PMF

TEST FLOOD DISCHARGE = 30500 CFS

TEST FLOOD ELEVATION = 590.5'

TOP OF DAM = 583.0 THEREFORE DAM EMBANKMENT WOULD BE OVERTOPPED BY ABOUT 7.5 FEET DURING TEST FLOOD CONDITIONS.

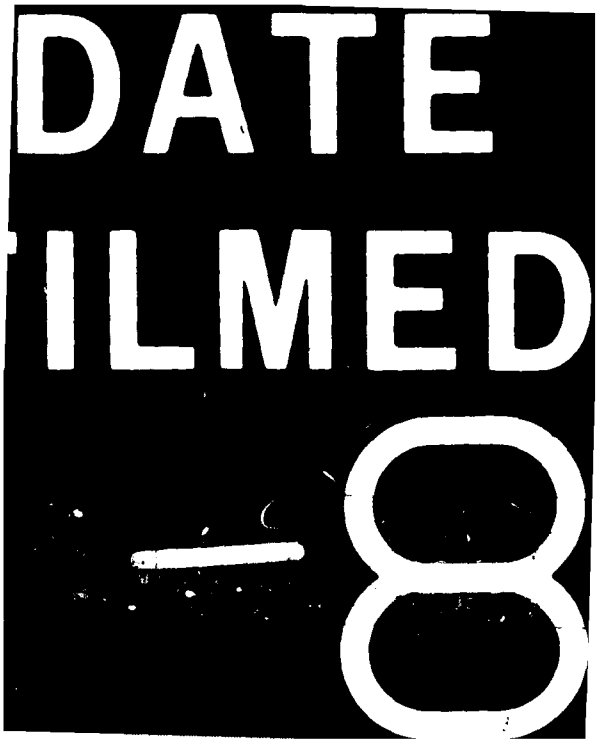
THE SPILLWAY CAPACITY AT TEST FLOOD CONDITIONS = 16071 CFS


605
595
585
575
ELEV. IN FT (MSL)
0
400
800
1200
1600
STORAGE IN ACRE FEET
BADGER POND DAM
STORAGE - ELEVATION

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME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8